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YORKSHIRE

Geological and Polytechnic Society.

NEW SERIES, VOL. XI.

1888—1890.

WITH TWENTY-ONE PLATES.

EDITED BY

JAMES W. DAVIS, HONORARY SECRETARY,

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NOTES ON THE VALE OF CLWYD CAVES, BY C. E. DE RANCE, F.G.S., ASSOC.INST.C.E., F.R.G.S., HONORARY MEMBER MANCHESTER GEOLOGICAL SOCIETY.

To realize the full significance of the facts lately discovered at Tremeirchion, on the east side of the Vale of Clwyd, and half-a-century ago at Cefn, on its western slope, it is necessary to review the evidence that has been obtained in other parts of North Wales, in Cheshire, in Cumberland, and especially in Lancashire, in which county a complete sequence of deposits can be determined from the commencement of the Glacial conditions down to the present time.

The upper portions of the Lancashire valleys are found to be what Professor Green has well called "valleys within valleys," the more ancient depression having been filled up with Glacial Drift, which has been re-excavated out, by the gradual denudation of the rivers running through them. The work of widening is effected by the outer bends of the "S"-like curves of the rivers, these slowly move their position in the direction of the flow of the stream, so that after a sufficient time has elapsed, the cutting bend of the "S" reaches the precise point which its predecessor occupied.

The Lancashire rivers have not only excavated wide valleys more than a mile across, like that of the Ribble at Preston, but have excavated them vertically to a depth of nearly 200 feet, the process going on until the *negative gradient* was reached of that particular stream from its source to the sea, below which denudation ceases, so long as the levels of the land remain constant.

Thus it happened that when the cutting bend of the "S" occupied the position of the similar curve of its predecessors, the stream level was vertically lower by the amount denuded during the period of the seaward progression of the curve to its predecessors position, consequently the silt and other material thrown down during floods, forming the alluvium of the stream, was deposited successively at lower and lower levels; such portions of these alluvial flats that have escaped subsequent denudation form terraces fringing the sides of the valley, the varying height of which mark the successive stages in the process of deepening the valley. The lowest alluvial flat still in process of formation, consists of a bed of loam above a peaty horizon, resting on coarse gravel.

On the western margin of the glacial drift upland-plains, great marine denudation has gone on, and lowland plains continuous with the most modern alluvial flat of the Ribble have come into existence, here the sequence is Blowing and Blown Sand, and *Scrobiculariæ* clays resting on thick-beds of peat, which between the Mersey and the Ribble rests on an ancient Blown Sand, which I have named the "Shirdley Hill Sand"; and between the Ribble and Wyre, upon an ancient shingle bed, I named the "Presall Shingle."

Following the thick peat of the low-level plains into the Ribble valley, it is found to be continuous with the peaty horizon of the lowest alluvium of that river, proving that the valley had been excavated to its full width and depth before the growth of the peat out in the low-level plains.

Examination of the peat deposits on the coasts of North Wales, Cheshire, Lancashire, and West Cumberland point to the land standing at a higher level in regard to the sea than at present. At a boring at the Palace Hotel, Birkdale Park, Southport, the peat horizon occurred 69 feet below high-water mark. In Liverpool Bay the fishermen constantly bring up pieces of peat in the trawls, at Rossal, Crossens, and Hightown in Lancashire, at Leasowe in Cheshire, and at Llanderillo-yn-Rhos in Denbighshire, the peat beds are seen extending down below high-water mark, and doubtless formerly passed beneath the level of low water, along which they have since suffered denudation ; borings also at Rhyl at the mouth of the River Clwyd in Flintshire establish the same facts, peat beds underlying Blown Sand and Estuarine Beds beneath the level of low-water.

Roman remains occur in the estuarine deposits overlying the peat beds of Leasowe, and near Fleetwood, and north of Rossal a large number of Roman coins were discovered in marine silt resting on the peat, which were probably lost by the Romans slipping about on the mud banks, at a period when the levels of land and sea were much as at present ; the position of the remains of a Roman Bath at Freckleton, west of Preston, points to the same fact, and no change of level appears to have taken place since Roman times.

The coarse gravels at the base of the Ribble Alluvium and the shingle in the plains between Garstang and Presall point to a period of considerable denudation, the sea wasting the Glacial Drift and forming the lowland plain which subsequently constituted an area of obstructed drainage, culminating in the growth of peat, and the rivers deepening and widening their main valleys to their present proportions.

The previous steps of fluviatile denudation and consequent fluviatile deposition of a small portion of the material denuded, appears to have proceeded along in similar lines, points to a recurrence of physical conditions, *first*, large gravel formed during a period of denudation, *second*, peaty beds with trunks of trees formed during a period of obstructed drainage, *third*, a period of tranquil deposition of fine loam. These conditions are marked in the sequence of deposits in the river terraces of the Ribble and the Irwell.

Reviewing the whole of the evidence afforded by the Post-glacial deposits, it will be seen that no geological work, or physical changes in level, or condition of the country appears to have taken place since the Roman era, but between the close of the Glacial episode, or at all events after the deposition of the latest glacial deposit and the advent of the Romans, the wide and deep valleys of Western Lancashire were excavated out of the Glacial Drift by fluviatile denudation.

The Glacial Drift of the north-west of England and the coast of North Wales is generally made up of an Upper Boulder Clay, reddish or brown in colour, traversed by vertical joints, in the neighbourhood of which the colour of the clay is generally of a leaden hue, it is obscurely stratified, contains rounded and semi-rounded pebbles and blocks, that had been previously ice-worn and scratched, probably by the action of coast-ice, shells of recent mollusca occur occasionally, but generally in a fragmentary condition, and have probably been derived from the gravel generally found beneath these gravels, or rather shingle beds associated with thick beds of sand, have been called the "Middle Drift," from their overlying a Lower Boulder Clay, where seen in section, as in the Bispham and Norbreck Cliffs, north of Blackpool, the banks of the Ribble Valley at Red Scar, east of Preston, the cliffs near Egremont, in Cheshire, and Mostyn, in Flintshire. The pebbles in the Middle Drift are invariably derived from the underlying or immediately adjacent local deposit, and are made up of fragments of coal, coal measure sandstones, or millstone grits, if these rocks underlie it, or of erratic pebbles derived from the Lake District, if the Lower Boulder Clay forms the underlying deposit. The sands are extensively current-bedded, generally in a S.S.E. direction, or that now taken by the tidal current flowing past the Mull of Cantyre, on the coast of Cumberland, and that of Morecambe Bay, where this portion of the tidal current now meets that flowing through St. George's Channel, which during the glacial submergence was not the case. Shells of recent mollusca occur plentifully in pebbly seams, the shells are generally fragmentary, but at Macclesfield, Leyland, Preston and Blackpool they occur in a perfect condition, and probably lived at the site of the localities, where they are found, when covered by the glacial sea, the species of many are northern, and resemble those now living at the North Cape ; in the peculiar thickening of the canal of the univalves, and the umbos of the bivalves, they resemble the shells of recent mollusca, brought back from Grinnel Land, by the late British Arctic Expedition. A similar assemblage of shells is found in the sands, occuring at very different levels, varying from that of the present high-water mark to 1,200 feet above it, it is probable that the deposits of the higher elevations are more modern than those of the lowlands, by the time which it took for the land to subside that vertical amount, and that the deposits were thrown down in water of a similar shallow depth, in all the sections examined. There is however evidence in a large number of borings, especially in the Coal-fields of Flintshire, Wigan, and Manchester, that a repetition of conditions took place, and that more than two boulder clays exist, and that considerably more than one horizon of sand occurs.

In some sections near Brinscall, and in other parts of Lancashire, the oldest glacial deposit consists of a tough stiff clay, with local fragments, which in places is seen to be overlaid by Lower Boulder Clay of the ordinary type, in which obscure traces of stratification are to be seen. As I pointed out many years ago [Nature, 1870] the same sequence is seen in the glacial drift deposits off the coast of North Wales : a Lower Boulder Clay with northern erratics lying on the eroded surface of dark leaden-coloured clay containing local fragments ; Sands and Shingle Beds resting on the Lower Boulder Clay with erratic fragments. These Sands and Shingle attain a thickness of nearly one hundred feet at Holywell, in the valley between the station and the town ; near Mostyn also they were seen in extensive sandpits, and on the opposite side of the Clwyd Valley they are seen interstratified with red Boulder Clays between Colwyn Bay and the Little Orme's Head. In the neighbourhood of St. Asaph, in the centre of the valley, these middle glacial beds have been dug for sand, and contain the usual assemblage of shells found in the same beds at various Lancashire and Cheshire localities. Between Mostyn and St. Asaph these sands were described by Dr. Buckland in the Reliquiæ Diluvianæ, London, 1823. He gives the following section of the Talargoch Mine, shafts not named :—

		Feet.
1.	Vegetable mould ...	2
2.	Clay	78
3.	Sand and Gravel ..	204
		284

He states that pebbles of lead and some pebbles of copper occurred in the gravel, and that horns, teeth, and bones of Mammalia occurred at from 40 to 70 yards from the surface, and also in the bottom bed resting upon the rock. Mr. Trimmer,* in 1836, states that two bones found at Talargoch Mine in a bed of gravel at 63 yards from the surface, associated with marine shells, were presented by Mr. Thomas Harrison to the Caernarvon Museum, the bones were described by Buckland as the *astragalus* of a large deer, and the *humerus* of a smaller species, Two perfect specimens of *Purpura lapillus* were shown to Mr. Trimmer found in the eastern end of the works. The bones found at Talargoch have got scattered over the country, but one is preserved in the Chester Museum, and has been identified by Professor Boyd Dawkins, F.R.S , as the left *ilium* of a bison. The gravel beds were also described as being worked for the rolled fragments of lead at Gronnant Mine by Dr. Buckland, the Glacial Drift being 104 feet in thickness. The following table by Mr. Strahan, F.G.S.,† gives the level of the base of the Drift below the ordnance datum level :—

	Feet.
At Talargoch Walker's Shaft ...	41
,, Prestatyn bore-hole	54
,, Foryd bore-hole	80

THE CAVES OF THE VALE OF CLWYD.

The scientific exploration of caverns appears to have sprung from the search after the "ebur fossili" or unicorns horn, in the deep caverns of the Hartz, Franconia and Hungary. So far back as 1603 Dr. Gesner had noted that this supposed specific for many diseases, was in fact the elephant's teeth, tusks, and other fossil bones. In 1672 Bauman's Hole in the Hartz was described in the Philosophical Transactions. In the following century the caves of Franconia engaged the attention of numerous German observers, and bones were identified by Baron Cuvier. The most important of these was the cavern of Gailenreuth, from which vast quantities of bones of hyænas, lions, and other animals were obtained. The year 1816 appears to have been the moment when public interest in these matters was greatest, and the experience of cavern exploration in Germany fully matured, which was the time chosen by Dr. Buckland for his visit to this remarkable cavern, in which he learned those methods of research which subsequently laid the foundation of all scientific cavern exploration in Britain. It was in this county, in the cave of Kirkdale, in the Vale of Pickering, 25 miles north-east of York, that Dr. Buckland first applied the knowledge he acquired at Gailenreuth, and proved by the most conclusive evidence that the cave had been inhabited by hyænas, who had gnawed the bones of their prey in the manner he had observed the modern hyæna of the Cape of Good Hope, gnawing bones of an ox in a menagerie.

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* On the Diluvial or Northern Drift of the eastern and western side of the Cambrian Chain by Joshua Trimmer, 1838, pp. 32-33.

† Geology of Rhyl, Abergele and Colwyn. Memoirs Geol. Survey, 1885.

The Victoria Cave, near Settle, was discovered by Mr. Jackson, in 1837, in a limestone scar 1,450 feet above the sea, and subsequently explored under his superintendence, by a British Association Committee, in 1870, 1871 and 1872. The section near the mouth was found to be as follows, according to Professor Boyd Dawkins[*] :—

	Ft.	In.
Post-Roman Talus	3	0
Romano-Celtic Stratum	2	0
Talus, with Neolithic horizon at its base	6	0
Grey Clay	4 0 to 6	0

The Grey Clay occupies the entrance and inside of the caves to an unknown depth, a shaft sunk to a depth of 25 feet near the entrance proved the following sections, in descending order :—

	Ft.	In.
Stiff grey clay, with stalagmite layer ...	6	0
Finely laminated calcareous clay	12	0
Stiff grey clay	6	0

A second shaft further in the caves failed to find the base of the clay at 12 feet, but a third shaft still further in the cave proved 4 feet of reddish loamy cave-earth to underlie about 5 feet of it. The cave-earth contains the bones and teeth of the same group of animals that occur at Kent's Hole, Wookey Hole, and other places, and that reached Europe before the commencement of the glacial episode.

Mr. Tiddeman, F.G.S., describes certain portions of the grey clay as being laminated like the boulder clays of Ingleton, and Clifton, near Manchester, where it was first described by the late Mr. Binney,

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[*] Cave Hunting, p. 87, London, 1874.

F.R.S., under the expressive name of "book-leaves." Professor Dawkins states that they occur at all horizons, and even under the cave-earth, in interstices between the large blocks of limestone underlying the cave-earth.

The Victoria Cave in many respects resembles the Caves of the Vale of Clwyd, in the Yorkshire Cave certain deposits alleged to be glacial rest upon the Bone-earth, but their age has been disputed in the Clwydian Caves, also the Bone-earth is overlaid by glacial deposits, the presence of which has been referred to Swallow-holes, and to a wash from older deposits. After careful study of the Welsh Caves, and all that has been written upon them, I think there is no doubt that they were inhabited by hyænas, and were visited by man before the submergence, during which the local glacial deposits were thrown down.

In the year 1832, the Rev. Edward Stanley, Vicar of Alderley Edge, afterwards Bishop of Norwich, and father of the late Dr. Stanley, Dean of Westminster, visited what was then called the Cefn Cave, a perforated arch through which the road is carried, in which he describes the occurrence of the bones of animals, stags' horns, and a human skull pierced with some sharp instrument. After examining this natural tunnel he heard that a new cave had been discovered 100 feet higher up on the hill, and about 40 or 50 feet below the summit, it was discovered in cutting a very extensive series of walks, by the owner Edward Lloyd, Esq., he found the new cave to have two entrances, the western being full of bone-earth, made of comminuted fragments of bone with numerous large bones of mammals, gnawed and crushed by hyænas, whose teeth were plentiful. He visited the cave in February, and again in April, and found the fine loam in it to fill up the cavern nearly to the roof, which he considered was formerly entirely sealed, he described the laminated appearance of the loam, and the occurrence of bones and broken pieces of hazel or birch.*

In 1836, Mr. Bowman† inferred from the presence of sand and gravel within 18 inches of the roof, that the cavern must have been a water-course.

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* Edinburgh New Philosophical Journal, Vol. XIV, p. 40-53.

† J. E. Bowman, Cefn Bone Cave, Brit. Assoc. Report, 1836.

The section he describes as consisting of :—

1. Impalpable mud lamined, 1ft. 6in. to 2ft. 0in.
2. Marl, or clay, with angular limestone waterworn pebbles, passing down into pure bone-earth, with hæynas, rhinoceros, 2ft. 0in.
3. Diluvial clay, pebbles of clay-slate, splintered bones and stalactites, 2ft.
4. Coarse and fine sand, loam, and clay, no bones or shells, 3ft. 0in.

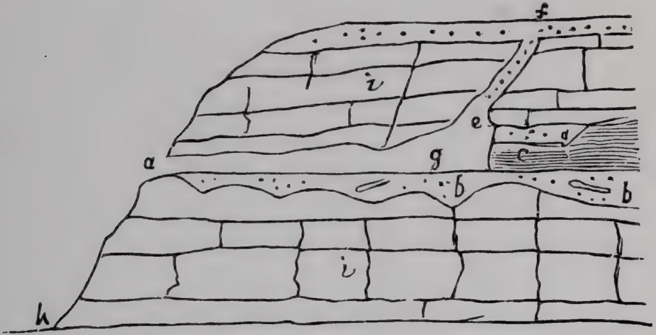

Figure 1. Cefn Cave [Trimmer.]

a. Level of Cave entrance.
b. Mud, with rounded pebbles of grauwache, limestone or wood, covered with stalagmite.
c. Mud, bones, and angular fragments of limestone.
d. Sand, silt, with fragments of marine shells.
e. Fissure.
f. Northern Drift.
g. Cave cleared of mud.
h. River Elwy 100 feet below cave.
i. Limestone rock.

Mr. Joshua Trimmer* in 1838 correctly described the position of the Cefn Caves, as being in a locality in which the local Cambrian Drift met with that derived from the north. He states the beds nearly filled the cavern to the roof, which communicated with the surface by fissures, and describes the Northern Drift as occurring both on the surface and in the fissures. He describes the sedimentary deposits filling the cavern as consisting in descending order of sand and marl, containing fragments of marine shells like those dispersed near the neighbouring district. He mentions that the sediment is very finely laminated, and that the bone-bearing loam was separated into two beds by a crust of stalagmite. The lower bed he states "was below the level of the entrance from the face of the cliff, and contains bones and teeth enveloped in sediment, and mixed with smooth pebbles like those of the adjacent river, and fragments of wood." The authors point out that the lower bed must have been formed by the river when it flowed at a different level, and the marks on the bones show that it was the home of carnivora ; and he points out that it must have been sub-ærial for a time, allowing the stalagmite to form.

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* Trimmer. Cefn Bone Cave. Brit. Assoc. Report for 1838-1839. *Also* Practical Geology and Mineralogy, London. John W. Parker, 1841, p. 400 etc.

Dr. Falconer visited Cefn Cave on August 27th, 1859. His notes appear in the "Palæontological Memoirs and Notes," edited by Dr. Murchison, London. 1868. Vol. II. p. 541-2, in which he gives a ground plan of the cave which I have verified on the ground. The tunnel on entering turns to the left, almost parallel to the face of the cliff, it then turns at right angles to it ; to the right is a steep side branch running a considerable distance upwards, with many sub-branches, which probably almost reach the surface. Further on the main tunnel divides, and afterwards again unites, a column or island of limestone being left in the centre, beyond which the tunnel ascends very steeply, and eventually reaches daylight on the other side. Of this opening Dr, Falconer says, "it appears to me to have been the *flue* through which most of the materials were injected and washed into the cave. The main tunnels have their floors covered with very slippery yellow loam. The injecta have been washed down chiefly into the left hand tunnel, where bones are found on the upper side of the insular irregular cylinder, around which the cave passage turns, and which forms a complete circular communication.

The following is a list of the species identified by Dr. Falconer amongst the fossils from Cefn Cave :—

Elephas antiquus.
Hippotamus major.
Equus, teeth and astragalus.

Rhinoceros hemitæchus.
„ tichorhinus.
„ Species undetermined.

Strongyloceros spelæus.
Bos, molars.
Felis spelæa.
Ursus spelæus.
Cervus Guettardi.
,, eurycerus.
Hyæna spelæa.
Canis lupis.

No reference is made to shells in the note of Dr Falconer, published by Dr. Murchison, but in the "Geologist" for 1863,[*] it states that the bones examined by Dr. Falconer, were in the possession of Colonel Watkin Wynn, and that Falconer and Professor Ramsay together discovered fragments of cockles and other marine shells in the clay, and amongst gravel and stones, with which the cave is filled.

Sir Andrew Ramsay referring to this discovery, states the Cefn Caves "were below the sea during part of the glacial epoch, for the Boulder Clay beds reach a higher level, and with Dr. Falconer I found fragments of marine shells in the cave overlying the detritus that held the bones of elephants and other mammalia."

Mr. Mackintosh, F.G.S.,[†] in 1876, gave the following sequence of the deposits at Cefn Cave :—

1. Coarse sand charged with minute fragments of sea-shells, still found adhering to one side of a rising branch ascended by steps.

2. Clay with angular and subangular fragments of limestone, likewise a few pebbles of Denbighshire sandstone, grit, and felstone. This deposit contains bones of a number of the usual cave mammalia, is horizontally continuous with the Upper Boulder Clay of the district.

3. Stalagmitic crust from less than an inch to 2 feet in thickness. Very little is described as left in Cefn.

4. Loam with rounded and smoothed pebbles, bones, teeth, and fragments of bone and wood.

The author agrees with Mr. Trimmer, that the sand with shells was introduced by the sea.

On the 22nd of May last, I made, in company with Mr. Bouverie Luxmoore, F.G.S., a careful examination of the cave, and we found portions of the sand-bed still adhering to the wall of the cavern near the upper steps, containing numerous small fragments of shells, one of which is believed to be referable to *Tellina Balthica,* the fragments were examined by Mr. Clement Reid, F.G.S., but no others were capable of determination.

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[*] Geologist, Vol. VI, p. 114, 1863.

[†] Quart. Jour. Geol. Soc., Feby., 1876, Vol XXXII, p. 91.

To Dr. Hicks, F.R.S., is due the great interest which now attaches to the caves of the Vale of Clwyd. This investigator visited St. Asaph in 1883, and after visiting the well-known Cefn and Plas Heaton Caves, in the carboniferous limestone of the western side of the Valley, he "was struck with the dissimilarity in the character of much of the materials which had apparently filled these caverns before they were explored," with that which he was conversant in South Wales, to the exploration of which he had previously given much attention. Mentioning this to Mr. Luxmoore, F.G.S., of St. Asaph, and enquiring for caverns on the eastern side of the Vale of Clwyd, he was taken by the latter to a cavern situated in a ravine at the back of Ffynnon Beuno, near the village of Tremeirchion, four miles to the east of Cefn. The cavern was subsequently explored by them. The floor was found to be 42 feet above the stream, and 380 feet above the sea, the slope between being covered with a reddish Boulder Clay, containing Silurian pebbles. The stream has not yet cut down to the original floor of the valley, while high up the valley, sand and gravel is seen containing fragments of sea-shells, on a level slightly above the highest cavern. Similar gravels occur in the gorge east of the Oratory, in the grounds of St. Beuno's College, at a height of over 500 feet. The Ffynnon Beuno cavern, on investigation, was found to consist of a main tunnel with entrance to the south, a small parallel tunnel to the west, also facing south, and a fissure cavern to the east, between which and the inner termination of the tunnel caverns is a considerable chamber, probably partly of a late and artificial origin, and connected with mining trials carried out through the fissure to the east, which has, or has been expected, to bear lead-ore.

A section of the main tunnel, about twenty feet from the entrance, disclosed the following section;—

1. Surface soil or loam about a foot thick, containing bones of domestic fowls and sheep.

2. Stalagmitic breccia with charcoal, &c., possibly of extremely modern origin, about six inches.

3. Reddish undisturbed cave-earth, about 2 feet in thickness

lying horizontal, and but slightly inclined, at the base was a more coherent yellowish bed, but not stalagmitic, with flint implements.

4. Gravel consisting of local materials, with angular blocks of limestone below.

The flint implement was discovered close to a large portion of the jaw with teeth of a rhinoceros, and close to it large fragments of limb bones of mammoth. The fissure cavern communicated with an opening to the surface, under this large masses of limestone and surface soil were found, which when removed, exhibited undisturbed earth, with many bones, and a few broken flint implements. In the line of the fissure undisturbed stalagmite was found, under which was cave-earth, mammoth teeth, and a well-worked implement. The implements were examined by Dr. J. Evans, F.R.S., who stated

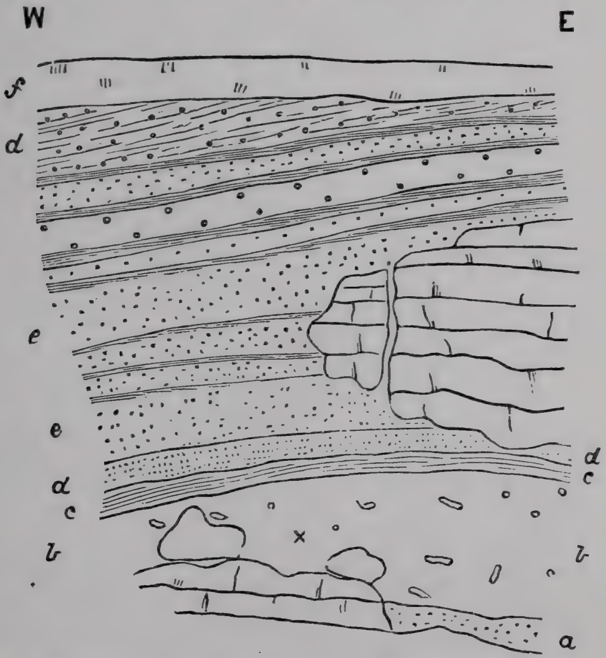

Fig. 2. Section across shaft, and western entrance of Cae Gwyn cave.
Scale. 8 feet to 1 inch.

a. Local Gravel. b. Bone Earth. c. Laminated Clay.
d. Banded Sand. e. Sand and Gravel. f. Soil, &c.
× Position of Flint Implements.

they resembled those found in Kent's Cavern, he states they have every indication of being used and have now a white porcellanous appearance.

When I examined the cavern with Dr. Hicks, the work of exploration was drawing to a conclusion, I found the fissure to have been extensively mined at some period, and with a rope followed it down some 40 feet below the level of the floor of the cavern.

The western small undisturbed tunnel was discovered by Dr. Hicks, and searching for still another entrance, he found the entrance into the cavern now called Cae Gwyn, this he discovered in 1884, he considered a portion of the entrance had been originally quarried away, and filled up with débris, on this being removed, a cavern was seen filled up with loam, to within 2½ to 4 feet of the roof, a small chamber, with a turn to the right hand was reached, and a trial made at 45 feet from the actual entrance, here under the loam, and underlying laminated clay, occurred bones belonging to Rhinoceros, Horse, Reindeer, and Red Deer, and a well-worked Flint-scraper, resembling those of the French Caves of the Reindeer period, according to Dr. Evans. The work in this cave was resumed in 1885, much débris had to be removed, and large masses of limestone had to be blasted that were found resting upon the gravel beneath.

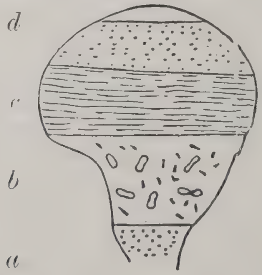

Fig. 3. Section in cavern near new entrance. ***Scale.*** **6 feet to 1 inch.**

- **a. Local Gravel.**
- **b. Bone Earth.**
- **c. Laminated Clay.**
- **d. Banded Earth.**

At the time of my visit in the autumn of 1885, the Cae Gwyn Cavern had been worked back as far as the supposed chamber marked

"B" in the plan of the cave published in the Quart. Jour. Geol. Soc., Feb., 1886, which plan I assisted Dr. Hicks in constructing, unfortunately, we did not connect it with the surface, and we were totally unaware that the cavern, by trending westwards, was upon the point re-emerging into daylight, not the slightest traces of subsidence was visible either in the roof of the cavern or on the surface of the field above.

The various deposits at the working face of the cavern filled it up to within 5 or 6 inches of the crown of the roof, consisting of:—

		Ft.	In.
1.	Fine washed yellow sand	1	0
2.	Laminated clay, &c.	1	6
3.	Red Bone-earth (fragments of stalagmites) ...	2	6
4.	Local gravel	1	6

The Sand resembled that seen in the Drift Sand Pit, 400 yards distant up the valley. On my next visit, 5th June, 1886, and on subsequent days, I found that the removal of material from below had caused a subsidence to take place, beyond what turned out to be a wall of limestone, in which the cavern terminated, and against which a mass of glacial drift formed a slope masking the limestone behind it. The subsidence was accelerated by the heavy snowstorm of the previous winter, the melting snow percolating into the sands, and along the plane between the rock and the drift.

A vertical shaft had been dug 20 feet in depth on the east, or cavern side, and 19 feet on the western side, 9 feet across at the top, and about 5 feet 6 inches at the bottom. I measured with Dr. Hicks the beds exposed in the shaft on all sides by means of a ladder. I placed the point of a knife at the intersection of each bed, and the measurements were written down, and checked by him. The section published in the British Association Report 1886, is the result of these observations. The dip was westwards from the rock, both above the cavern mouth and below it, as shown in the section. The whole of the material in the cavern was not then removed, and the fine grained yellow sand, resting on laminated loam overlying bone-earth, was then seen extending into the cavern to a distance of fourteen feet. Water was still coming in freely at the extreme north-east corner of the shaft, along a line of joint ranging north, to an unknown distance into the hill. But the yellow sand with oblique lamination, came right up to the rocky ridge overhanging the north of the cavern, and extending northwards beyond it, the sand-bed not only abutting against the rocky ledge but filling up hollows and inequalities in its surface; the overlying beds of boulder clay, associated with seams of sands, also abutted against the rounded mass of overhanging rock, as did the succeeding bed of fine sand a few inches in thickness, that could then be followed round the four sides of the pit, as could the boulder clay resting on it.

On my next visit June 17th, 1887, my colleagues, Messrs. Tiddeman and Reid, were present, the northern face of the shaft was boarded up; the shaft was carried westward to 11 feet from the inner wall of the cavern; no new phenomena were observable; the materials of the cave were almost entirely excavated out, and the north joint had become dry. I again visited the cavern on October the 3rd and on the 8th, in company with Mr. Shone, F.G.S. The timbering had been removed, and the north side of the shaft re-exposed. Professor Hughes was present, and had a small east and west cut made into the west bank of the shaft, which showed a slight trace of oblique lamination to the S.S.E., the direction so often met with in the Middle Drift Gravels of Lancashire and Cheshire. The joint was slightly yielding water; no new phenomena were observable.

On October 10th I again visited the cave, accompanying the Director-General of the Geological Survey, and Professor Hughes. Messrs. Hilton Price, F.G.S., Luxmoore, F.G.S., and E. Morgan were also present. Very heavy rains had fallen, and the pit was unfortunately in a soft and somewhat obscure condition. A large block of limestone was pointed out to Dr. Geikie, and he was correctly informed that others occurred at the mouth of the cavern, but he was not told that similar blocks occurred throughout the whole tunnel. A vertical band of sand or sand pipe was shown to him on the west face of the "tumbler" block before referred to.

The visit led to the following letter being addressed to Dr. Hicks by Mr. Archibald Geikie, L.L.D., F.R.S., Director General of the Geological Survey of the United Kingdom, which is of considerable interest:—

"The question on which my opinion was asked with reference to this cave, was, I understand, the following :—Whether the glacial beds lie undisturbed upon the bone-earth at the end of the cave, or whether their present position is due to the fall of the roof or wall of the cave, and their consequent descent upon the cavern floor.

Accordingly I visited the cave on the 10th inst., and examined the section laid open in the pit that was dug in the glacial deposits. The conclusions I formed may be summarized.

1. The bone-earth projects beyond the present limits of the cave, but it probably never did so originally, hence I have no doubt that the roof or wall of the cavern has given way. The large masses of limestone lying at the bottom of the pit no doubt represents a portion of the fallen material.

2. These fallen blocks lie on the bone-earth. The material resting upon them has, of course, been removed in the excavation of the pit, but I observed that the block nearest the northern wall of the pit passed under the base of the undisturbed glacial beds.

3. Against the lower part of the face of limestone on the northern side of the pit there is undoubted evidence of slipping, the lower layers of pebbly sand and clay being vertically against the end of rock. This disturbance however I could trace only a few inches outwards from the rock boundary. It does not affect the main mass of glacial deposits, and is referable I think to solution of the limestone along its outer surface. The various layers of gravel, sands and clays were traced by me continuously across the pit, I could see no evidence that they had ever subsided into a cavity, caused by the fall of the limestone into the cavern.

4. From the data presented by the pit section, I would infer that the fall of the roof or wall of the cave took place before the deposition of the glacial deposits, and that during a period of subsidence, these marine strata were subsequently laid down against the limestone bank, so as to conceal this entrance to the cavern.

16th October, 1887. (Signed) ARCH. GEIKIE.

Mr. Morgan, the lord of the Manor, having kindly promised to delay the process of filling up the pit until I had attended to make a last examination and sketches for Dr. Hicks, I again visited the cave on the 11th of October. Three sketches were then taken, showing successive stages of removal of the blocks. The north joint in the limestone is seen in Fig. 4, on the west side of it are masses of fallen limestone, now separated from it by a vertical pile of dark chocolate-coloured clay, with pale green fragments, about 4 inches in width. Examining the blocks more closely with Robert Williams, who was foreman of the workmen through the whole of the investigation, we very cautiously removed several, and found them to be imbedded in the ordinary brick red clay, with occasional erratics ; further removal of the large blocks disclosed a band of washed yellow sand, which could be traced round from the north joint westwards, over the large "tumbler" before referred to, and over the vertical sand pit also

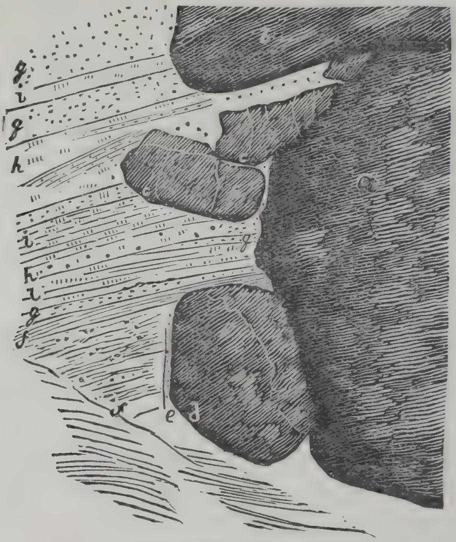

Fig. 4.

a. **Limestone wall, joint face.**
b. **Overhanging solid limestone.**
c. **Loose masses in Drift.**
d. **Large block.**
e. **Pipe of sand, against block d.**
f. **Bone earth.**
g. **Sand.**
h. **Gravelly Boulder Clay.**
i. **Boulder Clay.**

alluded to, cutting off its upward or vertical prolongation. The sand band now described is about 5 inches in thickness, and ranges horizontally when in contact with the north joint, but dips westwards along the northern face of the pit up to the next bank, where in common with the other beds at the lower part of the section, it dips southwards. Between this sand bed and the "tumbler" is a bed of red clay 6 inches thick. So far as I could ascertain this clay passes down behind the "tumbler," but we considered it dangerous to remove it and ascertain, as the whole bank might have been brought down on our heads.

The red clay up to a certain height contained bone fragments, and the teeth of a hyæna from the north, or clay joint up to and over the "tumbler" fragments of stalagmite were numerous, but I saw none above 2 inches in length, I observed no fragments of stalagmite or bones in the red clay above the laminated sand-bed. The sand pipe adjacent to the "tumbler" appears to owe its origin to percolation of water in the 5-inch sand-bed, which has carried the sand, filling up the fissure between the side of the block and the adjacent red clays, these latter are obviously the flow which arrests and throws out the spring at the north, or "clay joint," which has been similarly filled by the passage of water carrying Boulder Clay from above. The "saturation plane" in the rock beneath, I found by observations in the Fynnon Beuno Cave in 1885, to be but slightly above the stream level, the dryness of the tunnel-cave is due to the cap of Boulder Clay which overlies the hill, but the clay is not wholly impermeable, water traversing joints in it, to which process is probably due the infilling of the north joint with clay, as described.

I undermined the western bank of the Cae Gwyn pit for about 2 feet, the red bone-earth continued as far as we went, containing fragments of stalagmite and bone, there is no evidence to show how far westwards this deposit extends, traces of bone occurred at a point 5 feet from the overhanging ridge of the cave, and I think it a matter of great regret if the extent of its western prolongation be not settled.

From the facts observed during the past half century, it would appear that the following conclusions may be considered definitely settled.

That the caves of the Vale of Clwyd were inhabited by hyænas and other animals at a period, when man existed in the Vale of Clwyd, before the deposition of the middle and upper glacial deposits, but whether before the oldest glacial deposits, there is no evidence to show.

That the Vale of Clwyd like the valleys of the Ribble and the Mersey was deeper before the deposition of the glacial deposits than at the present time. That the valleys and plains of Lancashire, Cheshire, and the coast of North Wales were filled up with various Drift deposits.

That the existing valleys of Lancashire, Cheshire, and the coast of North Wales, have been excavated by the action of running water since the deposition of the Upper Boulder Clay.

That the great peat beds fringing the coasts of these districts are later than the period of denudation of those valleys in the Glacial Drifts.

That the period of the Roman occupation of Britain was later than the growth of the peat.

NOTES ON THE CLASSIFICATION OF THE PALÆOZOIC POLYZOA.

BY GEORGE ROBERT VINE.

The classification of Palæozoic Polyzoa, whether as Cyclostomata, Busk, Cryptostomata, Vine, or Trepostomata, Ulrich, is still incomplete. This arises from two causes, it may be from more causes still, but I wish to confine my remarks specially to two points only :—

I. The want of a suitably definite nomenclature, descriptive of the structural elements of the Zoarium, Recent and Fossil ; and

II. The want of ready agreement on the part of Palæontologists, as to what should, and what should not be admitted as Polyzoa, or Bryozoa.

Within the last few years the Palæozoic Bryozoa have been critically studied, both by means of the mass, and by sections of the species described, and at the present time we are in a better position to judge of the possibilities of future research, than we were at the beginning of the decade that is now drawing to a close. Since the commencement of my British Association Reports on Fossil Polyzoa in 1880, new investigators have entered the field, and if the good old proverb is true, 'many minds, many modes,' the results will be that the varied methods now adopted by Palæontologists, will ultimately enable us to look at the Palæozoic Polyzoa from different standpoints, so as to have an allround view of the same, rather than from one standpoint only. In my recently published paper, "Notes on Classifications of Cyclostomatous Polyzoa, old and new,"* I have done my best to gather together into one focus, much, if not all that has been suggested respecting the classification of the Mesozoic Polyzoa, and in the present paper I wish to do the same for the Polyzoa of the Palæozoic horizons. In the present case it will be wiser to deal with the suggested subdivisions separately, and in order of time.

In his valuable introduction to "American Palæozoic Bryozoa,"† Mr. E. O. Ulrich has given very elaborate details respecting the general structure of the Monticuliporidæ, and of "a great number of undoubted Bryozoa belonging to the sub-order Cyclostomata," which should be studied carefully by future investigators. Mr. Ulrich includes in his Bryozoa group, as do American authors generally, the whole of the Monticuliporidæ. These, however, are placed amongst the corals by English authors, such as Duncan and Nicholson. In the not-far-off future some species at least of the Monticuliporidæ will have to be retained as Bryozoa, in spite of the now general disposition to place them elsewhere, or we shall have to modify, considerably, our ideas respecting many of the Polyzoa of Mesozoic and Tertiary horizons. In the present paper I have excepted the Monticulipora until our British Silurian examples have been more carefully studied.

I.—Cyclostomata Busk. 1857, Published in 1859.

"Cell tubular : orifice terminal, of same diameter as the cell, without any moveable apparatus for its closure, consistence calcareous." Monograph of the Crag Polyzoa.

There is not, so far as I am aware, any insuperable difficulty of including the whole of the recent, semi-recent, and Mesozoic Polyzoa, under a description so well worded as the above. Most of the species that have come under my own observation may be definitely described as Cyclostomatous. The cells are tubular, the orifices in most cases are terminal, and though not all of the same diameter as the cell, the orifices are certainly without any "moveable" apparatus, still there were cell "closures" in Cyclostomatous, as well as in Cheilostomatous Polyzoa. It is not altogether then the preciseness in the above definition that causes any difficulty to the Palæontologist, whenever his investigations carry him beyond the Mesozoic horizons. For accurate descriptions of species here, however, the diagnosis is either too incomplete or too obscure, and this is felt to be the case by every naturalist who has taken the Palæozoic Polyzoa in hand.

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* **Proc. Yorks. Geol. & Polyt. Society, Part III, Vol. IX, 1888.**

† **Jour. Cinc. Soc. Nat. Hist., Vol. V., pp. 121-149.**

I have already referred to the labours of Mr. Waters on the semi-fossil, and fossil Cyclostomata,* but it will be necessary to refer to them again for the purpose of formulating a satisfactory nomenclature for speculative as well as for working students.

The Cyclostomatons "*Cell*" (Busk) "*Zoœcium*" (Hincks) "is the chamber in which the polypide is," or was lodged. It is wholly calcareous, and its structural elements are few and characteristic. If we take the "cells" of two species, *Crisia* and *Hornera*, and analyse them, we shall find material for formulating a definite working nomenclature, suitable for Palæontological investigations ; then, if some few of the Palæozoic species are submitted to the test, it will soon be found whether the ancient cell corresponds with the characteristic recent cell in all, or in any, of its elements. If not, then the question naturally arises as to whether it is wise to confine ourselves to one division for the Polyzoal group of organisms, or whether it will be necessary to establish other divisions in which many of the Palæozoic species can be satisfactorily placed.

In the cell of *Crisia*, (*cornuta*, *eburnea*, or *denticulata*) there are certain "punctures" evenly or sparsely distributed, which do not appear to have been separately studied either by Mr. Busk, or Mr. Hincks, but the punctures are partly referred to as characteristic of species both by Busk, and Hincks. In *Crisia eburnea* these "punctures" are thinly distributed, having a circular mouth, and on the sides of the cell we get a longitudinal aspect of the same, seen, however, to much better advantage whenever the walls of the cell are broken. The "punctures" penetrate the substance of the cell wall from the surface, opening, apparently on the inner side of the tube, In the more highly calcareous cells of *Hornera foliacea* similar punctures to those of *Crisia* may be observed, only they are larger, and even under a lower objective the punctured tubes show a longer section on account of the thickness of the cell-wall. In the dissepiments which connect the branches of the *Zoarium* the openings of punctures are larger, but many of these appear to be of a different character to those of the smaller openings in the cell walls.

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* Proc. Yorks. Geol. and Polyt. Soc,, pt. iii., vol. 9, 1888.

Mr. A. W. Waters' in his admirable paper on "Fossil Cyclostomatous Bryozoa form Australia,"* refers to the punctured surfaces of the Cyclostomata, and he suggests a possible homology between some of the lateral interzoœcial tubes and the rosette plates of the Chilostomata. Mr. Waters refers also to the almost general constancy of the size of these punctures in preparations he had made of Tertiary Cretaceous, and even Palæozoic species, "The structure is well shown, he says, in sections, figured by J. Beissel, especially in pl. x., fig. 127 in his paper, Ueber die Bry. der Aachener Kreide.† . . . These, I take it (the surface punctures) are the homologues of the much larger pores in the front of nearly all Chilostomata, which there also cause the Zoœcial ornamentation," p. 677, op. cit. I have already referred to the interzoœcial pores in the walls of the cell when sectioned, but Mr. Waters affords an illustrated instance, (pl. xxxi., fig. 24, *op. cit.*) in *Heteropora pelliculata*, Waters, in which a diphragm, or plate, seemingly perforated in the centre, occurs in the middle of the pore-tube, and thus it seems entirely to correspond to the simplest of the rosette plates among the Chilostomata," p. 677, op. cit. Mr. Waters also refers to the "surface pores" in other genera, such as *Entalophora*, &c. . . "but in some genera, such as *Hornera*, some *Idmoneæ* . . both living and fossil there are, over part of the surface at any rate, and sometimes over all, larger openings giving a peculiar ornamentation to the surface ; these larger surface openings do not, however, enter directly as such into the Zoœcial tube, but at the base there are one or more minute openings leading to the Zoœcial cavity," p. 678, pl. xxx., fig. 8., op. cit. In *Idmonea radians*, Mr. Waters says, "these large exterior openings occur at the junction of the Zoœcia," and Mr. S. O. Ridley in his paper on the Zoological collections made during the survey of H.M. Ship Alert,* refers to *Idmonea milneana* D., Orb., in which the "dots" (Busk, Cyclostomata, 1875, p. 12) of Busk's description are certainly *raised*." It is not improbable, then, that these "dots" or "punctures" may have a morphological meaning, not as yet thoroughly understood, but their study has yielded, to me at least, results that will be utilised further on, and we shall meet with another character in species of the *Heteropora*, that was partially referred to by Busk in the Crag Polyzoa.

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* Quart. Jour. Geo. Soc., Vol. 40 (1884), pp. 674-697.
† Nat. Verh. Holl. Maat. Weten. Haarlem, xxii., (e) Deel.

In his paper on "The Closure of the Cyclostomatous Bryozoa,"† Mr. Waters has furnished us with details of another structure, also available to the Palæontologist, especially so when dealing with Palæozoic species, and allied to, and possibly correlative with this structure are the so-called "teeth" in carboniferous Fenestella,‡ but perhaps not analogous with the "hair-like teeth which occur in several species of *Lichenopora*, which have globular terminations." (Bry. Bay of Naples, p. 276).

We are indebted to Mr. E. O. Ulrich for many hints while comparing the various species subjected to his scrutiny, that will be valuable to the student ; but it seems remarkable that some of these, drawn from the previous researches of D'Orbigny have been so frequently overlooked, or perhaps misinterpreted. The study of minute structures however in other groups are yielding ample results to the investigator, and I see no reason why the same comparative study of the minute parts of the cell should not yield similar advantages to the student of ancient organic forms.

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* Proc. Zool. Soc., London, Jan. 4, 1881, pp. 44-61. See also Tet. Cyclos., New Zealand Quart. Jour. Geol. Soc., Aug., 1887.

† Linn, Soc. Jour. Zoology, Vol. XVII, p. 884, pp. 400-404, Pl. XVI.

‡ Remarks on some Fenestellidæ, A. W. Waters, Transac. Geol. Soc., Manchester, 1878.

It is very certain then that some of the Palæozoic Polyzoa at least may be safely placed, according to the structural elements under the division Cyclostomata, but there are others which could not with any degree of satisfaction to the Systematist be so placed, and for the inclusion of these, two independent divisions have been established by myself and Mr. E. O. Ulrich, of America, which will now be separately considered.

Sub-Order. CRYPTOSTOMATA VINE. 1880-1.

Zoœcia sub-tubular, in section slightly angular. Orifice surrounded by a vestibule, or otherwise concealed.

As there has been a little misunderstanding about my labours when trying to classify Palæozoic Polyzoa, it may be as well to give a personal explanation of my own special work, or so much of it as will include the above sub-division. In my second report on Fossil Polyzoa, "British Association 1881," I reviewed all that was known in Great Britain about Palæozoic Polyzoa, and in that report special details will be found showing the position I occupied with respect to the then known British species. A few years previous to this Prof. H. A. Nicholson wrote several articles on American Devonian, and Silurian species,* and about the same time Mr. Robert Etheredge, jun.,† and the Messrs. Young, of Glasgow University,‡ published papers on carboniferous species. My knowledge of these Palæozoic forms was drawn from Murchison's Siluria (Lonsdale) Phillips' Geology of Yorkshire, and M'Coy's publications, together with the new work of these later writers. In compiling my British Association Report, I went over all the type specimens of the Palæozoic species in the School of Mines. At that time no one in England had wholly committed themselves to a new classification. Many authors followed either Morris's arrangement in his catalogue of British Fossils, or formulised suggestive divisions *en passant*. My earliest labours, for which Dr. Duncan and others blamed me, were directed towards modernising the classification so as to be more in accordance with Hincks and Smitt. These authors suggested that all future grouping of the Polyzoa should be based on the character of the "cell," or *Zoœcium*, rather than upon the mode of growth of the "colony" or *Zoarium*. In his work on British Marine Polyzoa Mr. Hincks says, "there is evidence ('I quote my own words from Brit. Assoc. Report, p. 2 of Report), however, (as I learn on the excellent authority of Mr. R. Etheredge, jun.), of the existence of a few Chilostomatous genera at least, within this epoch (Palæozoic), and probably the group is represented in the Silurian division of it,' a conclusion, which after the most careful research, I am unable to agree with."* In dealing with the Palæozoic genera, however, I was obliged to accept the dictum of other authors, hence I took Lonsdale's, Nicholson's and Messrs. Young's estimate as to what external characters were found in *Fenestella*, *Ptilodictya* and *Glauconome*, and worked accordingly, but none of the remarks which I offered in the reports were wholly founded upon the labours of others. Types of the various genera were sectioned, but not, perhaps, fully understood in all their details of structure. I was not at that time, 1879 and 1880, aware of the rich harvest of Palæozoic forms which was then being catalogued, and which have since been described by Mr. E. O. Ulrich, of Cincinnati. Had I been aware of these I should have been more careful before committing myself to a peculiarly British, rather than a general classification. I hope, therefore, future students of Palæozoic Polyzoa will bear these remarks in mind while reading over the observations I offer on my own and Mr. Ulrich's labours.

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* Geological Magazine, 1874. † Explanation of Sheet 23, Scotch Geol. Survey.
‡ Quart. Jour. Geol. Soc., 1874, and Ann. Mag. Nat. Hist., 1874.

In the year 1881 Mr. G. W. Shrubsole, of Chester, began the compilation of his paper on *Glauconome*, and as he had had some communications with Mr. R. Etheredge, jun., besides myself, respecting Palæozoic forms, Carboniferous and Silurian, I suggested to him the necessity of a new arrangement of the so-called Cyclostomatous forms. Mr. Shrubsole's idea was to suppress the upper Silurian name

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* In the report, details will be found of all the supposed species whose affinities were somewhat doubtful. Since this was written I have been compelled to modify this opinion, and in all probability examples both of Chielostomatous and Ctenostomatous Polyzoa existed in Palæozoic strata.

Glauconome Goldfuss, and retain the term for Carboniferous, as well as Cambrian, or Bala species. He adopted this, and I also favoured the suggestion, hence the paper presently to be referred to, came to grief before it was printed in the Journal of the Geological Society. For years Mr. Shrubsole and myself had been working amicably together, and I suggested that if he made the paper a joint one I would allow him to do the descriptive part, and I would furnish him with details of a new sub-order for publication. Accordingly, on June 21, 1882, a paper entitled "The Silurian Species of *Glauconome*, and a suggested classification of the Palæozoic Polyzoa," was read. The paper, as written, was never published, and an abridged report only was inserted, two years after, in the Journal of the Geological Society, 1884. There was, however, an abstract publication of the original paper inserted in the "Abstracts of the Proceedings of the Geological Society of London," No. 424, sessions 1881-82, p. 109 (June).* From the pages of the above work I now quote. "The authors discussed the history of our knowledge of the genus *Glauconome*, and especially of the Silurian species. They then characterised the genus, to which they refer only the Bala species, formerly regarded as identical with *G. disticha*, Goldf., but which they describe as *G. Sedgwickii* Shrubs. *Glauconome disticha*, Goldf., from the Wenlock of Dudley, is taken as the type of a new genus *Arcanopora*.

The authors then remarked upon the characters on which the classification of the Polyzoa is founded, drawn from the study of recent forms, and stated that throughout the Cainozoic and Mesozoic series no Polyzoa are known which cannot be referred to these recognised groups. Many Palæozoic forms are in a different case. The orifices seen on the surface are not, in many instances, the mouths of the cells, but those of what the authors call *vestibules* beneath which the true cell mouth is concealed. For these types they propose to found a new sub-order under the name of Cryptostomata, and characterised by having the Zoœcia sub-tubular, or in section, slightly angular, and the orifice surrounded by a vestibule or otherwise concealed. The families referred to this group are the Ceramioporidæ, Plilodictyidæ, and Arcanoporidæ."*

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* **See Note on Glauconome disticha, from the Bala beds, &c., by G. W. Shrubsole; also in the Geol. Magazine, August, 1882, pp. 381-382.**

In my Fourth British Association Report on Fossil Polyzoa, 1883, I did my best to classify the whole of the then known Fossil species up to the chalk. All my ideas were based on the "Cell" and its arrangement in the branch, and, with the exception of the following which I now consider as erroneous, such as placing *Ceriopora interporosa, C. similis*, Phillips, and *Hyphasmapora Buskii*, Eth. under the Genus Heteropora, I do not think the classification has been as yet superceded so far as British species are concerned.

In the sub-division Cryptostomata, and under the Family name Arcanoporidæ Vine, "*Zoarium* multiform, Zoœcia tubular or semi-tubular, orifice of cell obscured by vestibule, true orifice of cell unknown," I placed the following genera :—

Genus *Ptilodictya*, Londsdale.	Type *P. Lonsdalei*, Vine.
,, *Arcanopora*, Vine.	,, *Flustra ? paralella*, Ph.
,, *Glauconome*, Goldf.	,, *G. disticha*, Goldf.

[NOTE.—My chief reason for shifting the type of *Arcanopora* from *Glauconome disticha* to *Flustra ? parallela* was on account of the similarity of the "hidden cells," irrespective altogether of the character of the interspaces between the cells. The Geological Society objected to the destruction of *G. disticha* as indicated in the abstract already given, consequently this species remains the only British type of *Glauconome*.]

In October, 1882, four months after the abstract of our papers was published, nearly ten months after it was written, the first of Mr. Ulrich's Papers on American Palæozoic Bryozoa appeared. This and subsequent papers were published in the Journal of the Cincin. Soc. of Nat. History. From the first I hailed the publication with pleasure, but although I have differed from Mr. Ulrich in his estimate as to what are and what are not Bryozoa or Polyzoa, no offence on my part was contemplated. In his first paper, p. 151,†

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* Proc. Chester Soc. Nat. Sc., Ph. iii., 1883; and Silurian species of Glauconome, &c., by G. W. S. and G. R. Vine. Abridged, Quart. Jour. Geol. Soc., 1884, pp. 329-332.

† Jour. Cin. Soc. Nat. His., Vol. V.

Mr. Ulrich established a new sub-order which he named and described as follows :—

SUB-ORDER TREPOSTOMATA, ULRICH.

"This sub-order is proposed for the reception of the majority of the Palæozoic, and many of the more recent Bryozoa. The principal distinguishing features of the sub-order are :—(1.) That the Zoarium is composed of slender fasciculate tubes, which do not (as is the case in the *Cyclostomata*,) gradually enlarge as they approach the surface, but remain throughout nearly of the same diameter; and (2.) That at a certain point in the course of the tubes to the surface, they bend outward, more or less abruptly, and change in character." Five families in particular Mr. Ulrich places in this sub-division. They are :—

1. Family Ptilodictyonidæ, Zittel emend, Ulrich.
2. „ Stictoporidæ, Ulrich.
3. „ Monticuliporidæ, Nicholson.
4. „ Fistuliporidæ, Ulrich.
5. „ Ceramoporidæ, Ulrich.

In the first family is placed the Genus *Ptilodictya*, Lonsdale, and in the second the Genus *Cystodictya*, Ulrich, but both are differently characterized in the descriptions. In the *Ptilodictya* the external features are diagnosed, but in *Cystodictya* the external and internal features are characterized. "Sections show that the intertubular spaces are occupied by a vesicular tissue."* It is very evident therefore, that Mr. Ulrich accepted for his generic divisions very different characters from myself, he the structure of the *Zoarium*, I the character of the Cell only, and there could be no offence in placing my name *Arcanopora*, as a synonym of *Cystodictya*,† Ulrich, if the priority had been Mr. Ulrich's instead of my own. My placement, then, of two different Genera, *Flustra ? parallela*, Phillips, in close companionship with *Ptelodictya* is not the result of ignorance, but rather on account of the partially hidden cell, and so on with *Glauconome disticha*, Goldfuss. If, therefore, we are to depend upon the structure of the interspaces, all of which were well known to me long before I wrote, for our generic divisions then Mr. Ulrich is right and I am wrong ; but if the cell or *Zoœcia* is to form the basis of our suggested divisions, then our work must be left to the convenience or the inclinations of future workers.

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* Ulrich, op. cit., p.152.

† Jour. Cincin. Soc. Nat. Hist., April, 1884.

Since my labours commenced, the so-called *Ceramopora megastoma*, M'Coy,* has been removed from the Polyzoan group to the Cœlenterata, and in all probability *Ceriopora interporosa*, Phillips, will have to submit to the same fate. What other species will have to be removed I can partially anticipate, but the removal of these at least is justifiable on account of their peculiar structural elements.† Mr. Ulrich however, still regards these as well as the Monticuliporidæ generally, as belonging to the Bryozoan group.

We have, then, three sub-divisions, under which the Palæozoic Polyzoa may be placed, but whether it will be wise to retain the whole, remains for future workers to decide. My belief is that all may be safely retained, but so far as the grouping of the Palæozoic Polyzoa is concerned, a little more latitude must be observed, because we deal with more primitive structures than in the grouping of Mesozoic, Tertiary, or Recent species.

I have already, in my Fourth British Association Report on Fossil Polyzoa (1883), given the history of the general grouping of Fossil species, ranging from the Silurian to the Upper Cretaceous Rocks ; and, as already referred to, I have recently reviewed in this Journal the Cyclostomata of the Jurassic Rocks, I shall now show the tendency of modern systematic classification as regards Palæozoic species.

In his "Scheme of classification of the American Palæozoic Bryozoa,"‡ Mr. E. O. Ulrich arranges the Cyclostomatous group as follows :—

SUB ORDER CYCLOSTOMATA, BUSK.

I. FAMILY TUBULIPORIDÆ, BUSK.

Genus Stomatopora—Bronn : ranging from the Trenton.
,, Proboscina, Audouin.

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* Review of the Diastoporidæ, Quart. Jour. Geol. Soc., 1880.

† See a Paper by Nicholson & Foord, Ann. Mag. Nat. Hist., Ser. V., Vol. XVI, 1885.

‡ Journ. Cincin. Soc. Nat. History, Vol. v., 1882, p. 149.

Genus Berenicea, Lam.
,, Rhopalonaria, Ulrich.

II. FAMILY THEONOIDÆ, BUSK.

,, Scenellopora, Ulrich.

III. FAMILY ENTALOPHORIDÆ, REUSS.

,, Mitoclema, Ulrich.

IV. FAMILY FENESTELLIDÆ, KING.

,, Fenestella, Lonsdale.
,, Polypora, M'Coy.
,, Septopora, Prout.
,, Fenestralia, Prout.
,, Phyllopora, King.
,, Archimedis, Lesueur.
,, Lyropora, Hall.*

V. FAMILY ACANTHOCLADIDÆ, ZITTEL.

,, Penniretepora, D'Orb. = ? *Glauconome*, Lonsdale.

VI. FAMILY ARTHROMENIDÆ, ULRICH.

,, Arthronema, Ulrich.
,, Arthroclema, Billings.

In a later publication† Mr. Ulrich remarks, "More extended investigations of the large group of Palæozoic Bryozoa . . . . . have shown me that the classification (as given above) is in some respects faulty, and yet more incomplete." In two groups Fenestellidæ, King, and Acanthocladidæ, Zittel, Mr. Ulrich places no fewer than twenty genera, and he states that the same synopsis will be adopted in his work on the Bryozoa of the State of Illinois (Geol. Surv. of Ill., Vol. viii., not yet published, Aug. 1888). A few remarks on some of the genera retained by Mr. Ulrich may be of use to students of British Palæozoic Polyzoa, for it is useless to pretend that any of our rocks will ever yield such a wealth of forms, generic or specific, as the American Palæozoic Rocks have already yielded.

In our own Palæozoic Rocks we have abundant evidence of the presence of the following genera :—

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* Possibly three other Genera *Carinopora*, *Cryptopora*, Nich. and *Ptelopora*, M'Coy.

† Contributions to American Palæontology, Vol. i., May, 1886.

Stomatopora,—	several species, but Upper Silurian only.
Berenicea ?	Probably in Silurian rocks.
Rhopalonaria,	Upper Silurian and Carboniferous.
Entalophora,	Species, Upper Silurian.
Fenestella,	Silurian to Permian.
Polypora,	Silurian and Carboniferous.
Septopora,	,, ,,
Stictopora,	= Ptilodictya, Lonsdale and Vine, Upper Silurian.
Phyllopora,	Lower Silurian and Permian.
Ptilopora,	Carboniferous.
Goniocladia,	,,
Thamniscus,	Upper Silurian, Carboniferous and Permian.
Pinnatopora,	Lower Silurian and Carboniferous.
Glauconome,	Lonsd., Upper Silurian.
Acanthocladia,	Permian.
Synocladia,	Permian.

Mr. Ulrich retains *Hemitrypa*, Phillips, but Mr. G. W. Shrubsole* has already shown, from the examination of type species, that so far as British examples are concerned, *Hemitrypa* is an untenable genus, and cannot stand. The whole of these genera are given as Cyclostomatous in the 1882 paper of Mr. Ulrich, but I cannot say whether he will retain the same sub-division for the emended grouping. So far as my own experience goes, only a few of the genera given above can be so placed, but before a satisfactory arrangement can be made, typical species of every genus will have to be described by sections, both of the Cells and of the Zoarium, in accordance with the now general mode of dealing with minute structures in other groups of fossil organisms.

II. Sub-order Cryptostomata, Vine.

In my fourth Report, (British Association, 1883). I gave a description of the minute structures of a species of so-called *Ptilodictya*, Lonsdale. It is well known that Lonsdale indicated that his genus and species were similar to, if not identical with *Flustra lanceolata*, Goldf. In all probability this was an error, as the small specimens selected by me for *P. Lonsdalei* do not correspond with Goldfuss's species otherwise than in its feather-like arrangements. In a note Lonsdale says "This coral is considered by Goldfuss to be a *Flustra*,* but it is placed by Milne Edwards among the doubtful species of that genus, (2nd Ed. Lamk, pt. ii, p. 219). From *Eschara* it differs in not having a central partition. I have ventured to propose the above name taken from the feather-like arrangements of the middle and lateral cells."† Only one species is placed in the genus by Lonsdale, *P. lanceolata*, Lonsd., and he remarks "Small fragments of probably young specimens of this species are occasionally found in the shales of Wenlock limestone." It is from fragments so abundantly distributed in the Wenlock shales that I selected the types of my species *P. lonsdalei*. The *Eschara scalpellum*, Lonsd., is present in the Wenlock shales also, though not so abundant. It is certainly not an *Eschara*, neither is it a *Ptilodictya*, in the same sense as the type species of Lonsdale or Goldfuss. In my classification I except this species as I am still doubtful where to place it. The *Ptilodictya interporosa*, Vine, according to the arrangement of Mr. Ulrich, is a *Stictoporella*, and not a *Ptilodictya*, hence we have only the two species *P. lanceolata*, Lonsd., Dudley limestone, and *P. lonsdalei*, Vine, in our British rocks, if the British species are retained as *Ptilodictya*, Lonsd., and not as *Stictopora*, Hall.

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* Quart. Jour. Geol. Soc., 1879, pp. 281-2.

The careful study of British species, at that time including *Eschara scalpellum* as a *Ptilodictya*, led me to remark of Phillips' *Flustra? parallela* = *Vincularia*, id. M'Coy, "I . . . prefer to leave the *Flustra* which Phillips describes with the *Ptilodictya* as *P. parallela*, and this reference is founded upon original investigation of various specimens of *Ptilodictya*, &c."‡ This might have been an

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*NOTE.—*Flustra*, according to the definition of Goldfuss and Linnæus, is as follows:—FLUSTRA, Linn., stirps foliacea, flexiles, lapidescens, cellularium seriabus in utraque pagina, e basis frontis radiantibus quasi contexta.—Petrifac, p. 32. FLUSTRA, somewhat stony, submembranaceous, and flexible, on a thin crust, consisting of contiguous cells, set in many regular series, on one or both surfaces; cells sessile, short, oblique, with a terminal, irregular, frequently dentated, or ciliated margin.—Brown's Zoologists' Text Book, 1st Ed. 1833, p. 566.

† Silurian System 1839, p. 675. Redefined by M'Coy, Brit. Pal. Foss. 1847, (= *Sticktopora*, Hall).

‡ Brit. Assoc. Report on the Carb. Polyzoa, 1880, p. 2 of Report.

error of judgment on my part, but no great sin at a time when so little was known about our British species. Since then my knowledge has been widened, and I owe to Mr. Ulrich's friend, and my own, Mr. J. M. Nickles, ample American material from the Cincinnati rocks, to show that the location may have been a bad one. I quote my own remarks, and I will later on reproduce my original illustrations, which were drawn for the purposes of the Report in 1879. The structure therefore which formed the basis of the character of *Cystodictya*, Ulrich, were known to, but not fully appreciated by me at the time I wrote. In the same report,* however, I separate the *Sulcoretepora Robertsoni*, Young & Young, from *F.? parallela*, remarking that *S. Robertsoni* is destitute of the non-poriferous, rugose, and striated margins of *F. parallela.* It is upon the presence of this particularly constant character that I refer Phillips' species to *Ptilodictya*." This correction of my former work was needful, and I make no apology for its introduction here. The remark however does not apply to my nomenclature of the minute structures of *P. lonsdalei*, Vine, which I used as the basis of the sub-divison CRYPTOSTOMATA.

"*Zoœcia* tubular, sub-tubular, in section (occasionally) slightly angular. *Orifice* of cell surrounded by vestibule, concealed."

I am not prepared at present to say what species will be included in the group, but I wish the student to bear in mind that my arrangement is based upon the "cell" rather than upon the surroundings of the cell, and that I still retain *Ptilodictya lonsdalei* (Stictopora ?) and its peculiar structures as typical of the division.

III. SUB-ORDER TREPOSTOMATA, ULRICH.

There are several species in British Silurian Rocks that may be conveniently placed in this sub-order, notably the Pseudo-Polyzoan forms referred to in the Fourth British Association Report (p. 45 of Report). Many of these species are still awaiting description and illustration, but I have preferred to keep them in abeyance till the report of Mr. E. O. Ulrich is published ; but the groups *Monticulipora* and *Fistulipora* have been so ably handled by Prof. Nicholson and A. H. Foord,[*] that I feel it would be mere folly on my part to suggest polyzoal affinities for species that have been placed in the genera indicated, by these competent authorities.

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* Ibid, p. 8 of Report.

In his review of the "Bryozoraires,"[†] Dr. M. Gustave Dolfus suggests that the general classification of the Bryozoa is indispensable to a good description of species, and after reviewing the work that has been accomplished by Hincks, Smitt, Busk, Waters, Pergens and others, he gives a resume of what has been done by M. Koschinsky and M. Waagen, the first on the ancient tertiaries, (Eocene), of Bavaria, the other on the Fenestellidæ of the Carboniferous rocks of India.. I have not seen M. Waagen's work, but Dr. Dolfus furnishes, in the review referred to, some account of the grouping of Palæozoic Polyzoa by this author. The arrangement is different from that ordinarily received, but I give it on the authority of M. Dolfus (op. cit. p. 186).

Family 1.—Fenestrellinæ.	1839,	Fenestrella, Lonsdale.
	1858,	Fenestralia, Prout.
	1859,	Septopora, Prout.
	1857,	Lyropora, Hall.
	1844.	Ptilopora, M'Coy.
	1883,	Helicopora, Claypole.
	1842,	Archimedis, Lesueur.
Family II.—Polyporina.	1844,	Polypora, M'Coy.
	1849,	Phyllopora, King.
	1849,	Synocladia, King.
	1876,	Dendricopora, Koninck.
Family III.—Goniocladinæ.	1876,	Goniocladia, Etheridge, jun.
	1875,	Ramipora, Toula.
Location Doubtful.	?	Disticheia, Sharp.
	1874,	Carinopora, Nicholson.
	1874,	Cryptopora, Nicholson.
	1876 ?	Protoretepora, Koninck.
		=? Phyllopora, King.

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[*] Annals and Mag. Nat. Hist., Dec., 1885, pp. 406-517,

[†] Extrait de l'annuare geologique universal. Tome iii., 1887.

In Dr. Lindstrom's "List of the Fossils of the Upper Silurian Formation of Gotland,"* the following species are placed after the Brachiopoda, under the head "Bryozoa," p. 13.

1. Monticulipora fibrosa, Goldf.
2. ,, petropolitana, Pander, var.
3. ,, ostiolata, Hall.
4. ,, Fletcheri, Edw. and Haime.
5. ,, ? pulchella, Edw. and Haime ?
6. Chætetes Bowerbankii, Edw. and H.
7. Trematopora solida, Hall.
8. Discopora sqamala, Lonsdale.
9. Cladopora repens, Linn.
10. ,, sparsa, Hall.
11. ,, seriatoporides, E. and H.
12. Cœnites juniperinus, Eichw.
13. ,, orientalis, Eichw.
14. ,, linearis, Ed. and H.
15. Ptilodictya lanceolata, Goldf.
16. ,, tessellata, His.
17. Retepora reticulata, His.

It would be unfair to the author if I did not make some reference to the labours of Mr. James Hall, of the New York State Museum, of which he is the principal Palæontologist. In the year 1847 the first volume of the Palæontology of New York was published. In it the author describes and illustrates (pl. iv.) several species of Polyzoa or Bryozoa from the Chasy and Trenton Limestone, which he names *Retepora, Gorgonia ? Stictopora, Escharopora* and *Intricaria.* Other volumes followed in successive years, the last one, VI., appearing quite recently, in all of which new, or little known Bryozoa, are described and figured. Since Mr. Hall began his labours on the Bryozoa new methods of procedure have been introduced into the study of the group, consequently conflicts between the favourers of the new or the old methods have been frequent, and at times, severe. It has not been my happy lot to side with either party, and in these notes I have done my best to be fair all round. If, then, I take two horizons of Mr. Hall's, which have been fully catalogued, the Upper and the Lower Helderberg groups, I shall be able to give a pretty full synopsis of the generic, but not the family grouping of the author.

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* Stockholm, 1885. Privately printed. See also Dr. Lindstrom's paper Ann. Mag. Nat. Hist. Ser. iv., Vol. xviii., p. 5., et. seq.

Lower Helderberg Group.[*]=Upper Silurian.

Of the grouping in this horizon Mr. Hall says "The fossils in this enumeration are designated as Corals and Bryozoans, the line of demarcation between the two classes in the genera Chætetes, Trematopora and Callapora being at the present time not satisfactorily determined." Mr. Hall further states that the revision of his previous paper (1874), together with the description of the new species here included, gives an expression of our knowledge of these groups of fossils up to 1878.

Genus	Aulopora, Goldfuss	Five	species.
,,	Vermipora, Hall	Three	,,
,,	Striatopora, Hall	One	,,
,,	Michelina, De Koninck	One	,,
,,	Favosites, Lamarck	Six	,,
,,	Chætetes, Fischer	Six	,,

The whole of these genera are described as "Corals" by Mr. Hall, and the following as "Bryozoans."

Genus	Trematopora, Hall	Nine	species.
,,	Callopora, Hall	Thirteen	,,
,,	Lichenalia, Hall	Three	,,
,,	Ceramopora,[†] Hall	Four	,,
,,	Paleschara, Hall	Three	,,
,,	Stictopora, Hall	One	,,
,,	Escharopora, Hall	Four	,,
,,	Fenestella[‡] Lonsdale	Twenty-five	,, and Vars.
,,	Icthyorachis, M'Coy	One	,,
,,	Thamniscus, King	Five	,,

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[*] 32nd Annual Report on the State Mus. Albany, 1880.

[†] This includes *Berenicea maxima*, Hall, 26th Rep., N. Y. S., Mus., 1874.

[‡] Including the so-called "Hemitrypa" species.

1881. Upper Helderberg Group.=Devonian.

In this paper the "Bryozoans of the Upper Helderberg and Hamilton formations" are described. Mr. Hall in a note says that he has "included a few forms of Chætetes, which from their structure can scarcely be separated from Favositidæ, while the differences between this genus and Trematopora is hardly determinable by any well-marked characters. Under the Fenestellidæ, I have not recognized the genus Polypora, though describing species with from two to four ranges of cells on the branches. The numerous examples of this variation have rendered the distinctions between the genera obsolete."

Genus	Chætetes, Fischer	Four	species.
,,	Trematopora, Hall	Six	,,
,,	Callopora, Hall	Three	,,
,,	Lichenalia, Hall	Nineteen	,,
,,	,, Sub-genus Phractopora,	One	species.
,,	Thallostigma, n.g.	Three	species.
,,	Stictopora, Hall	Nine	,,
,,	Intrapora, n.g.	One	,,
,,	Thamnopora, n.g.	One	,,
,,	Prismopora, n.g.	Two	,,
,,	Scalaripora, n.g.	Two	,,
,,	Glauconome, Goldfuss.	Three	,,
,,	Thamniscus, King	Two	,,
,,	Cystopora, n.g.	One	,,
,,	Clonopora, n.g.	Two	,,
,,	Crisina, D'Orbigny	One	,,

Genus Fenestella (Miller), Lonsdale, Sixty-three species,
Including Fourteen bracheted (Hemitrypa).

In addition to the above lists I have by my side a carefully compiled MS. Catalogue of Palæozoic Bryozoa, by my friend J. M Nickles, in which he enumerates, including Hall's species up to 1887, the names, together with a few synonyms, of nearly 1,500 species, American and Foreign. It is very certain that this amazing wealth demands the closest scrutiny, and to deal with all the *minutiæ* which links together group with group, is beyond my powers. To attempt classifying such vast masses of mixed forms on the old lines of a varying Zoarium, or on the possession of a more or less number of cells to the branch, as in the *Fenestella*, is a task I leave to others. Yet so far as our own *Polypora* are concerned it seems to me not a wise grouping to found a family name *Fenestellidæ*, on account of the banding together by dissepiments of the branches of a form, regardless altogether of the structure of the cells and the Zoarium. I am well aware that in the rocks of the Niagara group, and also in our Dudley limestone there are species with alternating branches, bearing two and three rows of pores, yet so far as I have been able to study the forms superficially, both the branches and the cells differ from those of *Polypora*. My material of the species is however too limited to warrant a more critical opinion.

At the beginning of this paper I specified two wants—

1st, a suitably definite nomenclature descriptive of the structural elements of the Zoarium ; and 2nd, a ready agreement on the part of Palæontologists as to what should, and what should not be, admitted as Bryozoa.

In the details given above, I think I have justified this necessity in dealing with Palæozoic forms. It now remains for me to carry the work a step forward by asking, in the interests of Palæontology, plainly—What are Polyzoa ? What are the marks in the Zoœcia or Zoarium which distinguishes the group from all other groups ? I do not ask in the interests of either biology or of ordinary natural history, because both the Biologist and the Naturalist can resort to the living animal or to well-sectioned tissues for the solution of nearly all their difficulties. Besides special memoirs we have the introduction to Hinck's British Marine, and Dr. Allman's Monograph of the Fresh Water Polyzoa. These works, however, do not sufficiently describe the Zoarium of the more calcareous Cyclostomata so as to be of use to the Palæontologist, but good work has been attempted nevertheless. Mr. Waters* very accurately describes my own views on the subject as well as proposes to me a problem which still awaits solution, but of which this paper is the first instalment. He says,—" Although it would be impossible here to give a

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***Fossil Cyclostomata from Australia, Quart. Jour. Geol. Soc., Vol. 40, pp. 679-680.**

complete history of all that has been attempted in the way of arrangement, we must mention the efforts of Dr. H. Hamm."* Dr. Hamm, however, in his new classification and on very slender basis creates fourteen new genera of fossil Cyclostomata. "It is not new genera or families that are wanted ; the real difficulty is to deal with and show the connection of those now used." Further on (p. 680) Mr. Waters says "Mr. Vine has brought together in the British Association Reports a vast amount of material bearing upon the classification of the Cyclostomata up to the age of the Cretaceous. . . . For my own part I much doubt if we are yet in a position to frame anything approaching to a natural and final classification of the older forms, but this opinion may arise from my extremely small acquaintance with Palæozoic Bryozoa ; but neither do I think we have nearly arrived at that point with the recent and neozoic forms, and until this is the case we can hardly expect to be quite sure about the older ones ; and I have often urged upon my friend Mr. Vine that more information concerning the minute structures would be most valuable from so good a worker." In answer to the question what are Polyzoa—

Mr. Hincks says† "The Polyzoa are almost universally composite animals, forming colonies of considerable extent, which are the products of repeated continuous gemmation." In every Polyzoon we distinguish two fundamental elements, the ZOŒCIUM and the POLYPIDE. These are the primary Zooids in every colony." Professor H. A. Nicholson says ‡"All the Polyzoa live in an associated form in colonies . . each 'Polyzoarium' (or colony) consists of an assemblage of distinct but similar Zooids arising by continuous gemmation from a single primordial individual. The colonies . . . are in many respects closely similar to those of many of the Hydroid Polypes . . . . The 'Polyzoarium' or 'Cœnecium' however of a *Polyzoon* differs from the Polypidom of a composite Hydroid in the *general* fact that the separate cells of the former do not communicate with one another, otherwise than by the continuity of the external integument, whereas the Zooids in the latter are united by an organic connecting medium or cænosarc." Mr. Hincks describes the "Rosettenplate" of Reichert as a "diaphragm, pierced by one or more minute orifices, occurring in the walls of the adjacent cells amongst the Cheilostomata . . . by means of which, communication is maintained between all the cells of a colony. . . ." I have already quoted a passage from Mr. Waters' paper on the Cyclostomata, in which the following remark may be found, but I give it again in connection with the above. In *Heteropora pelliculata*, Waters, there is a plate or diaphragm "seemingly perforated in the centre, it occurs in the middle of the pore-tube, and thus it seems entirely to correspond to the simplest rosette-plates of the Cheilostomata."* Mr. Busk observed "The Polyzoa are always associated into compound growths, made up of a congeries of individuals, which though distinct, yet retain some degree of inter-communication." From all this we glean the fact that in recent species of Polyzoa, a means of inter-communication do exist between cell and cell, both in the Cyclostomata and the Cheilostomata, and inferentially we may conclude that such means might have existed in the cells of true fossil forms of Polyzoa as well.

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* **Die Bry. des Mastr. Ober-Senon, 1 Th. Cyclos, Berlin, 1881.**

† **Introduction Brit. Marine Polyzoa. pp. i and iii.**

‡ **Manual of Palæontology. Vol. I, p. 414, Ed. 1879.**

As regards the affinities of the Polyzoa, much diversity of opinion exists. In his work on Palæontology† Professor Owen says "The *Bryozoa* are allied to the compound *Ascidia*, but not one of the Ascidian Molluscoids quit the ovum as a gemmule swimming by means of cilia, and no Bryozoon quits the ovum in the guise of a cercarian or tadpole, to swim abroad by the alternate inflexions of a caudal appendage . . . . The Bryozoa, whether regarded as the highest organised Polypes, or as the lowest organised mollusca, or as an intermediate type, are treated of in systematic Palæontology in the position here assigned to them. The practical Palæontologist finds himself compelled to arrange and study the Bryozoa along with the corals, if only on account of the difficulty he, in *many* cases, experiences of determining which class of Polypi his specimens belong to." Mr. Hincks condenses the opinions of several naturalists in a few brief paragraphs in his work on "British Marine Polyzoa," p. cix. "They have been ranked among the worms by Leuckart, Gegenbaur, Schneider, and Ehlers, the two latter authors placing them near the *Gephyræa*; Barrois, though doubtful, inclines to connect them with the Rotifera; Reichert would approximate them to the Cœlenterates; Milne Edwards, Agassiz, Allman, Huxley, Ray Lankester, and others, either refer them to the Mollusca or place them in a dependency of this sub-kingdom, the Molluscoida. . . . . . I shall confine myself in a great measure to a statement of the grounds on which I hold that the Polyzoa are essentially Molluscan."

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* Quart. Jour. Geol. Soc., Vol. 40, p. 677.

† Edition 1860, p. 27, &c.

Unfortunately for science, the promise shadowed forth in the preface to the monograph of the Silurian Fossils of the Girvan District in Ayrshire was not fully carried out. In the preface to the first Fasciculus, Messrs. Nicholson & Etheredge, jun. state (p. viii):— "The only point about the corals worth mentioning is, that we have thought it advisable, in the meanwhile, to retain such forms as *Chætetes* and *Fistulipora*, in the *Actinizoa*, rather than keep them back till we come to deal with the *Polyzoa*. It may ultimately be shown that these forms should properly find their place among the latter, but this view cannot be regarded as proved, and there are considerable difficulties in the way of its adoption." The Polyzoa, so far as I am aware, have never been described as yet from the Girvan district.

In his work on the Genus Monticulipora (Ed. 1881), Professor H. A. Nicholson has entered fully into all the characteristics of the development, affinities, and systematic position of Monticulipora (pp. 56-78), and I believe that a close study of this part by the student of Fossil Polyzoa will dispel many loose ideas repecting the Zoological position of the group. Many of Professor Nicholson's remarks are based on Foreign, rather than British species, and my pretty full knowledge of Silurian forms, founded upon thousands of examples from the Wenlock Shales, compels me to draw a line at true MONTICULIPORA, and not to include in the group forms that may, with some propriety, be placed much nearer to Polyzoa than to Monticulipora. I take, therefore, no exception to Nicholson's generic characters, but I select the following as a special diagnosis :—

(*a*) Corallum, composed of closely approximated tubular corallites.

(*b*) Walls of Corallites, never absolutely amalgamated.

(*c*) Walls imperforate, and septa entirely wanting.

(*d*) Tabulæ always present, generally complete.

(*e*) The presence of "Monticules" and "Maculæ"; areas elevated and depressed.

The above I consider a fair analysis of the Corallum, but Professor Nicholson has made us his debtor in his further studies of members of the group in his fresh contribution on the Genus Fistulipora M'Coy,* by adding a useful working nomenclature of parts of the Corallum, which will supersede the terms used in his "Monticulipora," and "Palæozoic Corals."

(*f*) Autopores = "large corallites" of the above works.

(*g*) Mesopores = "interstitial tubes" ,,

(*h*) Acanthopores = "spiniform corallites"

(*i*) Corallites, only used in a general sense when referring to the tribes of which the colony is made up.

As the true opposite of this nomenclature the following may be suggested as applicable to Polyzoa, and partially adopted from Mr. Hincks.

I. Zoarium (= Polyzoarium). The composite structure formed by repeated gemmation.

II. Zoœcium (= cell). The chamber in which the polypide was lodged.

(*a*) Cell wall ornamented by foramina (= punctures, Busk).

III. Cœnecium = the common dermal system of a colony.

IV. Ectocyst (= ectoderm). The outer layer of the Cœnecium.

(*b*) Ectocystal tubes. Tubes nominally ornamental of the Cœnecium, but which penetrate this layer.

(*c*) Interectocystal tubes. Tubes horizontal to the Ectocyst.

V. Endocyst. The inner layer; valuable to the Palæontologist as a reference whenever the Ectocystal tubes penetrate the substance of the Endocyst.

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* Dr. H A. Nicholson and A. H. Foord. Ann. Mag. Nat. Hist. Ser. v., Vol. xvi., pp. 496-517.

VI. Funicular opening and Endosarcal passages. The opening at the bottom of the cell, and the interspaces between cell and cell.

VII. Gonocyst. The inflation of the surface of the Zoarium, in which the embryos are developed (= Ovicell).

As this paper will be followed by others, wholly devoted to the structural characteristics of the Palæozoic Polyzoa, it may be well to refer to remarks in my first paper on DIASTOPORIDÆ,* "It is clear . . . that the Palæozoic representatives of the family Diastoporidæ differ very materially from the more recent members. If the whole are to be classified under one family name, a course highly advantageous to the study of Polyzoa, it will be necessary to take into consideration the more prominent characters, and place the species of the different formations under suitable genera," consequently I suggested the following arrangement :—

Recent and Tertiary	Genus I.—Diastopora, Johnston.
Secondary	,, II.—To be re-worked.
Palæozoic (in part)	,, III.—Ceramopora, Hall.
Palæozoic (in part)	,, IV.—Berenicea, M'Coy's description restricted.

Since then *Ceramopora megastome*, Vine, has been re-worked by Mr. John Young † and Messrs Nicholson & Foord,‡ and the carboniferous form is now placed as a synonym of *Fistulipora* (Calamopora) *incrustans*, Phillips. I have no objection to the synonym, for it is in good company, and I refer to it now because the re-study of the form by these esteemed authors has brought out a most valuable structural feature in this species, and in *Fistulipora* generally. "This consists of a very peculiar modification of the walls of the autopores which give them quite a distinct *facies*. The autopores possess a strong fold which imparts a trilobate or floriform aspect to the cells." The sinus is minutely described by the authors, and as it has a decided morphological significance, I refer the student to the closer study of the autopores of the Monticuliporidæ, taking as his guide the valuable paper on the Genus *Fistulipora*, M'Coy, by Nicholson & Foord.

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* Quart. Jour. Geol. Soc , Vol. XXXVI, 1880, pp. 356-361.

† Annals and Mag. Nat. Hist., Dec. 1882, pp. 427-431, and Trans. Geol. Soc., Glasgow, 1883, pp. 244-250.

‡ Ann. Mag. Nat. Hist., Ser. V., Vol xvi, p. 500.

NOTES ON THE ANCIENT ENTRENCHMENTS IN THE NEIGHBOURHOOD OF WETWANG. BY REV. E. MAULE COLE, M.A.

In 1882 Major-General Pitt-Rivers published the paper read by him the previous year before the British Association at York, on the Earthworks of the Yorkshire Wolds, with a map illustrating the district referred to.

The accompanying map is drawn to show the mass of entrenchments, lying further to the West and South, untouched by the paper above mentioned. By his excavations in the earthwork, commonly called Danes Dike, at Flamborough, Major-General Pitt-Rivers has established the fact that that famous entrenchment was constructed by a people who used flint weapons, and apparently had no knowledge of bronze. He expresses an opinion that the tumuli and entrenchments on the Wolds are of a similar age; but, quoting Canon Greenwell's authority, he goes on to observe that the tumuli were raised by a people in the early bronze phase of civilization, as bronze knife-daggers and celts of an early type had been found in them. This may be true of some other area, but not of the one before you, which contains some 300 British barrows, opened by Mr. J. R. Mortimer, in none of which was any bronze found.

The tumuli and entrenchments were doubtless to a certain extent contemporaneous, though instances can be pointed out where an entrenchment has evidently been diverted for the purpose of avoiding a tumulus. If, therefore, any preference as to age must be given, it should be in favour of the tumuli.

The entrenchments are not all of the same kind; some are merely tracks running along the brow of a steep dale, hollowed out originally to a depth of four or five feet, the earth thrown up on the lower side forming a slight rampart; these are mostly filled up now. Then there is the single dike, a mound (dike) with a ditch; and frequently "double dikes," two parallel mounds with corresponding ditches; and in several places three mounds; at Garrowby and Millington Lings four mounds, and at Huggate no less than five. These latter will be described later on.

The above entrenchments serve to cut off promontories to connect the heads of dales, or else to fortify the water-parting, occasionally to afford access to springs, and apparently to supply lines of communication with the coast on the high ground ; but, as a rule, they do not enclose any particular area as a fortified post. Fimber is an exception, and probably Aldro, and one or two other points. As a rule they run down the sides of dales, but do not cross the bottom. There are, however, exceptions, as e.g. the double dikes at Fimber. It is very rare for an entrenchment to be carried along a dale bottom, but there are a few instances, as at Backdale, pointing for Aldro.

A great many of the entrenchments marked on the map were determined by the Ordnance Survey, but numerous additions have been made by personal observation carried on for the last twenty years. After the inclosure of the Wolds at the beginning of the present century, the land was brought into cultivation, with the result that many of the old entrenchments were destroyed by the plough. The site of such may still be traced by an experienced eye, though the process of identification is sometimes slow. For instance, in a field of oats just before harvest, a couple of parallel green lines may be seen, whilst all the rest is turning brown. The surface soil is perhaps perfectly level, no sign whatever of an entrenchment. One has to wait four years before taking another observation, or, if circumstances are not favourable, perhaps eight or twelve years. Then, if the green lines re-appear in identically the same direction, it may be confidently asserted that the greener corn is growing in the filled-up ditches of an old entrenchment. In this way field has to be linked with field till the restoration is complete. And here another guide steps in, for in the hedgerows a rounded elevation may often be seen in the otherwise level outline of the top of the hedge. When the hedges were first planted at the inclosure the mounds were then in existence, and the hedges ran over them. All has been ploughed level since in the open field, but the hedge protects the portion of mound under it, and, in a district where the hedges are so neatly trimmed as on the Wolds, the eye can readily catch the rounded line of hummocks in one hedgerow after another. Again in turnip fields, white lines of chalk may occasionally be traced marking the *debris* of the ploughed-down dike or rampart.

By a reference to the map it will be seen that there are three prominent groups of entrenchments, viz., at Aldro, Garrowby Hill, and Fimber ; whilst three long lines start from the Western brow of the Wolds, and are continued for miles in the direction of Flamborough. The eastern extremities of two of these are figured in the map of Major-General Pitt-Rivers, one terminating above Wold Newton, the other above Butterwick, in the Great Wold Valley. The western extension of the former is shown in the map (Pl. I.) passing through Sledmere, Fimber, and Fridaythorpe, and probably connecting with Garrowby Hill ; that of the latter is continued in its westerly course from above Lutton to Burdale, and may have joined on to Aldro. A third line not alluded to by the General started from opposite Millington, and was carried by Huggate Dikes to Wetwang ; thence to the monument erected to the late Sir Tatton Sykes, and on by Kilham to Bridlington. All three lines are more or less connected by branch dikes, and present a remarkable network of fortifications such as can hardly be found in any other part of England. I use the word "fortification" because General Pitt-Rivers, looking at the eastern portion of them with the eye of a soldier, has pronounced them admirably adapted for defence against hostile attack from the North West, and thinks that they were principally constructed for that purpose. He adds that in the part which he examined he "found no well-defined example of a dike which appeared to have been thrown up as a defence against the east side." In the western portion now before you this latter statement can hardly be sustained, for the "single dike" at Fimber, with its ditch outside, is clearly a defence against the south east. The same may be said of the "double dike" running past the monument to Cowlam Dale, which crosses to the northern side of a lateral dale, and defends an approach from Driffield.

At first sight the long line of entrenchments stretching from Millington to Wetwang, and again from Foxcover to Wetwang, as also from Fimber to Sledmere and Fimber to Life Hill, seem to favour the view of defence from the North West ; but I am inclined to think that the nature of the ground had a great deal to do with the position of the entrenchments in these localities, for the northern and western sides of the dales are much steeper and loftier than the opposite sides, which gradually slope away, and the impression left on my mind is that the steeper sides were fortified as a defence against an enemy advancing up the dale bottoms, whether from east or west. In every case the defenders would have the advantage of the higher ground. If this view is correct it will partly account for the strong position at Fimber, which guards the entrance leading up to the curiously ramifying dales above, whether in the direction of Thixendale or Sledmere, and also for the entrenchments which cross the dales leading up to Huggate, and Huggate Dikes from the east.

Fimber appears to have been strongly fortified on all sides. The area enclosed is about one mile in length by half a mile in breadth. A plan, with sections of the dikes, was published by the Rev. T. Wiltshire* in the year 1862, with the assistance of Mr. R. Mortimer, of Fimber.

Coming now to Huggate Dikes, it may be confidently affirmed that they are, with the exception of the so-called Danes Dike, the most remarkable entrenchments on the Wolds. They consist of five parallel ramparts running across the table-land or water-parting at the head of two dales, one of which slopes eastward to Wetwang and Driffield, the other south west to Millington and Pocklington. From a map published by Dr. Burton, of York, in 1745, it is clear that they then existed from one dalehead to the other, a distance of half a mile, but a large portion has since been ploughed down, though distinctly visible to a trained eye. The part which still remains intact is in a grass field, called Huggate Pasture, forming a portion of the Rector's glebe. I am happy to be able to state that the present Rector, the Rev. J. R. Jolley, of Her Majesty's household, proposes to take steps to prevent any further destruction of these interesting antiquities. The length of the existing western portion is 220 yards. It is divided into two parts by an original opening or gangway about 100 yards from the west end. I was at one time in doubt whether this passage had not been cut through the dikes at some later date, but repeated examination of the ground has convinced me that the ramparts were intentionally terminated at this point, so as to admit of a level passage through.

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* **Proceedings Geological Association, 1862**

The dikes are not strictly parallel ; they are somewhat wider at the west end than at the east, and are only approximately straight. The following are the measured distances from the top of one ridge to the top of the next, going from south to north :—

At centre of West end ...	36 ft.	29 ft.	28 ft.	33 ft.
„ East „ ...	29 ft.	27 ft.	25 ft.	32 ft.

Counting the external ditches the extreme width at the west point of measurement is 193 ft., at the east 145 ft. As Dr. Burton, who made careful measurements in 1745, gives the width as 219 ft., it is possible that an outside rampart existed on one or both sides, which has since been destroyed by the plough.

The two dales, whose extremities terminate at Huggate Dikes, are of great depth, as much as 200 ft., and the sides are very steep. The high ground between is the only level piece on the Wolds on this line, and here would be concentrated any hostile attack whether from north or south. Hence the great strength of the entrenchments at this point.

Were the entrenchments on the Wolds the work of the Britons or of the Romans ? I have no hesitation in saying of the former ; for one reason, and that a good one, that there is not a straight line amongst the whole lot. They may look straight on paper, but not on the ground itself. Dr. Burton, in 1745, spent a great deal of time and money in preparing his map. It embraces the district round Millington, because he was persuaded that the long lost Delgovitia, a station mentioned in the itinerary of Antonine as lying between York and Prætorium, was at Millington. In support of his view he claims all the earthworks at Garrowby and Huggate as Roman works, and more marvellous still, all the tumuli as Roman barrows ! The tumuli are without exception British. Such being his views we need not be surprised at finding on his map the Huggate Dikes, half a mile long, ruled as straight and exactly parallel, as Euclid could desire ; whereas, as a matter of fact, they are quite the reverse. In my opinion the Romans attacked the hardy Brigantes of the Wolds on two sides, from York and from Malton, and a good many entrenchments may have been constructed by the natives during the long-continued fighting which doubtless went on then. The Romans had the best of it, and drove their roads right through some of the strongest points of vantage, so as the better to keep their enemies in subjection. Hence the roads from Malton to Londesborough, and from York to the coast, which cross on the top of Garrowby Hill. Also the road from Malton to Beverley, which crosses the said road from York to the coast at Fimber. This junction is very instructive. The York road passed through the centre of the entrenched camp, and made for the "double dikes" at the eastern side; whilst the Malton road destroyed part of the northern "double dikes," and completely severed the eastern extension. The three roads above mentioned all bear the name of High Street. The ancient British road from York to the coast also ascended Garrowby Hill, and was apparently utilized by the Romans as far as within two or three miles of Fridaythorpe, when the roads diverged, the Roman road passing by Sledmere to Bridlington, the British track passing by Holmfield and Wetwang to the Monument, and on to Kilham and Bridlington. The latter seems to have been protected by ramparts a great part of the way. It is interesting to note that this ancient track forms the boundary for every parish between York and Bridlington. I do not mean the present green lane, because that only dates from the inclosure, but the line of entrenchments. Just to give one example there is a long narrow strip between the green lane and the entrenchments on the Sledmere side, comprising seven acres, but this strip does not belong to the parish of Sledmere, but to Wetwang. A similar feature may be pointed out in the parishes of Garton and Kilham.

It does not appear then that the Romans had any fixed station in the area of my map, unless it be Fimber. It is just possible that after subduing the district, the Romans extended the old British works by making the "single dike" on the south side, known as Croom Dyke, a section of which is given by Mr. Wiltshire. The position would command both roads, that to Malton and that to York. The view from the hill top, Fimber Field, is most extensive, especially to the south and east. In this case Fimber may be the lost Delgovitia, as already suggested by Knox* and Phillips,† As far as distances are concerned, it agrees exactly with the miles given by Antonine, and repeated by Richard of Cirencester, where Derventio is given as VII Roman miles from York, and Delgovitia XIII from Derventio, XXV more takes one to Prætorium on the Coast. If this was the route at all,* I have little doubt that Prætorium was at Bridlington Bay, the "sinus salutaris," "portuosus sinus," also "Gabrantvicorum sinus." The Romans would never risk rounding the rock-bound coast of Flamborough Head, (Brigantium Extrema), when they could meet with such a capital landing place and shelter as the modern Quay.

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* **Eastern Yorkshire.** † **Yorkshire.**

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*Note.—Considering that the first iter of Antonine gives a list of Roman stations, starting from Northumberland, through Catterick and Aldborough to York, and thence to Prætorium, I cannot myself believe that this military way turned at right angles to Bridlington and Filey, but think it must have maintained a southerly direction. Still it could not go at first directly south from York, for the great plain south of York was probably all forest and more or less swampy, and crossed by several tidal rivers. The road from Danum, (Doncaster), made at once for the ridge of magnesian limestone on the west to Tadcaster, thence to York by another ridge at Bilborough. That from York to Prætorium might reasonably make for the Wolds, by the ridge running by Holtby to Garrowby Hill, thence southwards through Warter and Londesborough, to Brough on the Humber. The itinerary of Richard agrees with that of Antonine, but Richard gives some further particulars, he mentions the military road from Lincoln to the Humber, (ad Abum), where, he says, you cross into the province called Maxima, i.e. Yorkshire. The distance from the point of embarkation to that of landing or rather Petuaria, he calls VI miles, i.e. somewhat about 5½ English miles. The swift tidal current might easily make the passage longer than the present measured distance, which is somewhat less. Anyhow, Petuaria can have no more to do with Beverley than Prætorium with Patrington. Richard goes on to say that the distance from Petuaria to York is 46 Roman miles, which agrees with the former statement (the words "ut supra" can only refer to iter V), that the distance from York to Prætorium is 45 miles. Hence I conclude that Petuaria and Prætorium are really the same place, namely, Brough, and that the road to York passed along the western escarpment of the Wolds to Garrowby, through Londesborough, though whether Londesborough is the site of Delgovitia, as suggested by Drake, or Millington, as claimed by Dr. Burton, or Warter, as proposed by Mr. R. Mortimer, or Market Weighton, as doubtfully proposed by others, I do not pretend to say.

The following is a list of some modern maps bearing on the subject of the paper :—

1745. J. BURTON, M.D.—A Survey of the Roman Works in Yorkshire where the ancient town of Delgovitia is supposed to have stood.

1836. J. WALKER.—Ancient military remains on the western promontory of the Wolds.

1846. C. NEWTON.—Map of British and Roman Yorkshire.

1852. J. WRIGHT.—Britain under the Romans, from "The Celt, the Roman, and the Saxon."

1852. J. PHILLIPS.—The territory of the Brigantes, from "Yorkshire."

1855. R. KNOX.—A map of the country near Scarbro', from "East Yorkshire."

1862. REV. T. WILTSHIRE.—Plan and sections of the entrenchments at Fimber.

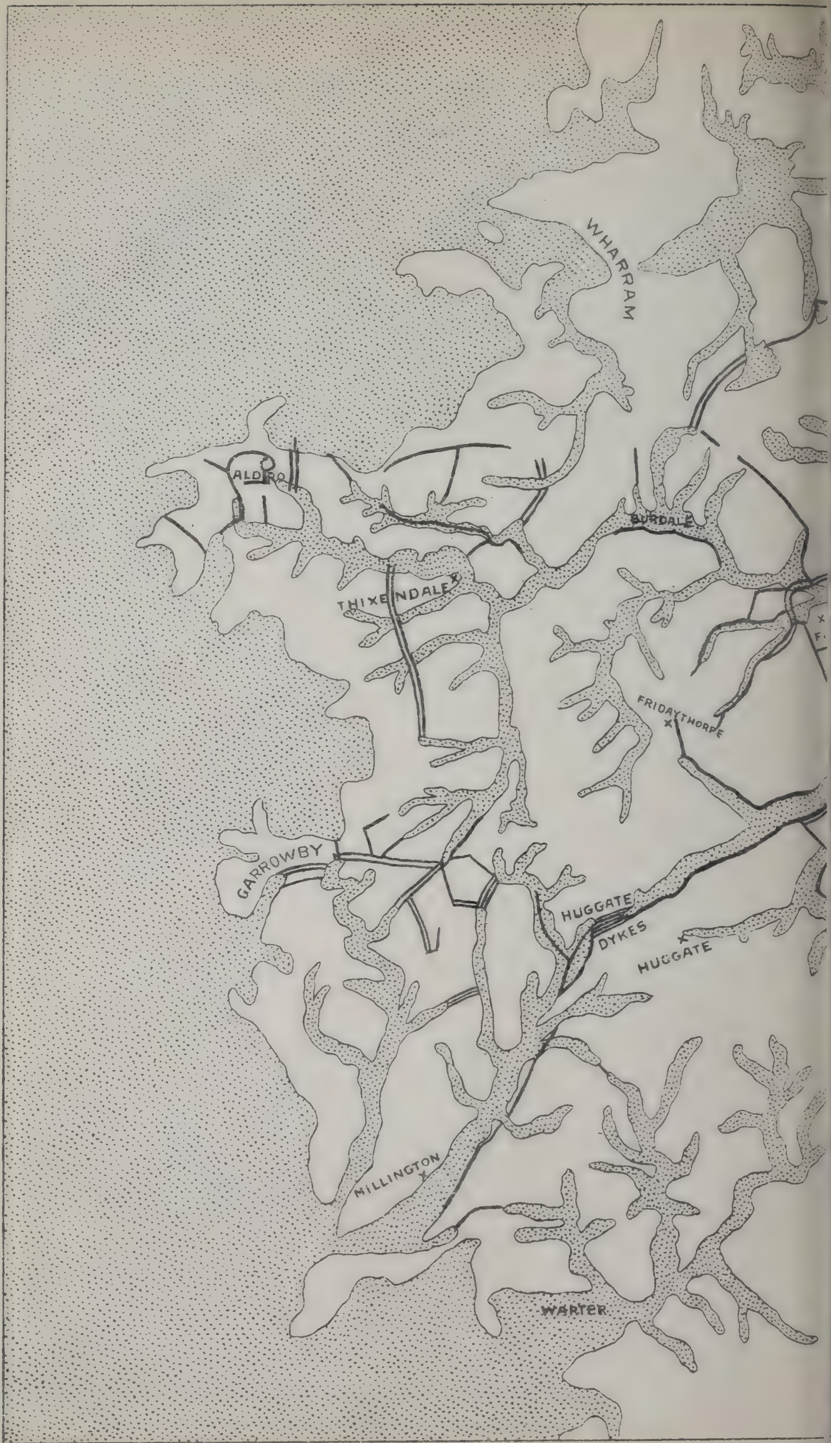
1882. MAJOR-GENERAL PITT RIVERS.—Map of the country near Flamborough Head, showing the positions of the Dikes.

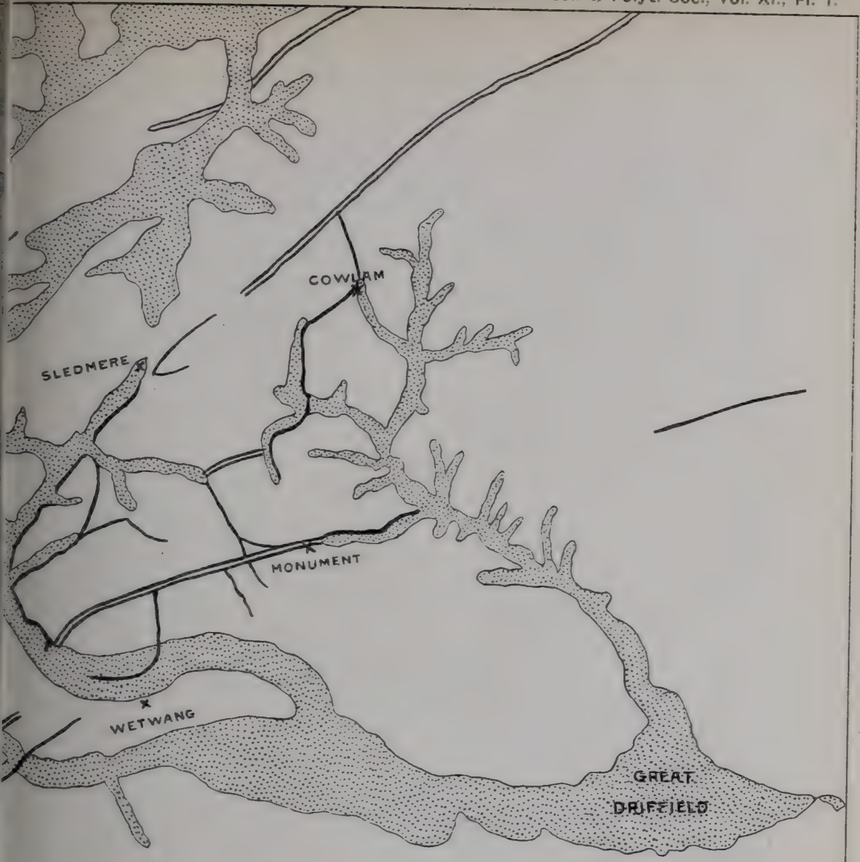
1886. R. MORTIMER.—Restoration of ancient entrenchments on the Wolds.

The following are the itineraries quoted :—

ITINERARY OF ANTONINUS.

Iter 1.	A limite, i.e., a Vallo, Prætoria usque,		m.p. clvi.
	A Breminio	*(High Rochester)*	m.p. xx.
	Corstopitum	*(Corchester)*	
	Vindomora	*(Ebchester)*	m.p. ix.
	Vinovia	*(Binchester)*	m.p. xix.
	Cataractoni	*(Catterick)*	m.p. xxii.
	Isurium	*(Aldborough)*	m.p. xxiv.
	Eburacum	*(York)*	m.p. xvii.


WHARRAM
ALDRO
BURDALE
THIXENDALE
F.
FRIDAYTHORPE
GARROWBY
HUGGATE
DYKES
HUGGATE
MILLINGTON
WARTER



ANCIENT ENTRENCHMENTS NEAR WETWANG.

REV. E. M. COLE.

Derventione	?	m.p. vii.
Delgovitia	?	m.p. xiii.
Prætorio	?	m.p. xxv.

ITINERARY OF RICHARD.

Iter v.	A limite Præturium usque		
	Corstoplio		m.p. xx.
	Vindomora		m.p. ix.
	Vindovio		m.p. xix.
	Cattaractoni		m.p. xxii.
	Eboraco		m.p. xl.
	Derventione		m.p. vii.
	Delgovicia		m.p. xiii.
	Præturio		m.p, xxv.
Iter xvii.	Ab Anderida [Eboracum] usque,		

* * * * *

	Lindo	*(Lincoln)*	m.p. xxx.
	In medio		m.p. xv.
	Ad Abum	*(Humber)*	m.p. xv.
Unde transis in Maximam.			
	Ad Petuariam		m.p. vi.
	Deinde Eboraco, ut supra		m.p. xlvi.

THE MESOZOIC ROCKS OF THE NORTH-EAST COAST OF IRELAND.

BY W. J. E. BINNIE, B.A., TRIN. COLL., CAMBRIDGE.

The grandeur, so distinctive of the scenery of this coast, is due to the nature of the materials of which it is composed. There are many who have heard about the columnar rocks of the Giants' Causeway, but few know that it is not so much on the ground of possessing such objects of interest as the Causeway or Fair Head, that this coast lays claim to be one of peculiar geological interest.

Here, in one narrow strip, we find the only representatives in Ireland of those Mesozoic deposits, which occupy such a broad expanse of country in England. Whether they were at one time deposited, and have been afterwards removed by denudation, or whether the geological history closed for Ireland in the carboniferous period, to be taken up again in the tertiary, must ever remain a matter of doubt.

While the north coast rejoices in the presence of these peculiar deposits, it is also characterised by the absence of the carboniferous limestone, the deposit *par excellence*, of which the rock surface of Ireland is composed. The deposits before mentioned, are invaluable in proving the western extension of their English equivalents, and indicating by their texture and contents, that we are approaching the limits of the area of deposit. Within the confines of the limited area under consideration, there is one of those coal-fields, which are all too few for the manufacturing prosperity of Ireland, for, though the carboniferous limestone occurs in Ireland in such great force, the deposits which followed it, unless protected by some special agency, have been everywhere removed. The preservation of these exceptional deposits is in a great part due to the capping of the basalt, to which the distinctive characters of the scenery of the coast are due.

The coast section of the plateau may be roughly described as occupying two sides of a triangle, starting from Belfast, it trends roughly N.N.W. as far as Bengore Head, a distance of 40 miles, where the line changes to W.S.W., and stretches in this direction for about 25 miles as far as Dungiven. The outline of the plateau is very irregular and broken, it is above the 500 feet line throughout its entire course, except where it is broken by the river Bann and other smaller streams; occassionally it rises into mountain peaks of 1,500 feet. This altitude is no doubt owing to the basalt, which everywhere caps the older formations, thus protecting them. Barrois describes this plane as resembling a miniature Auvergne where the craters have been removed; he describes the flow as rectangular, the two adjacent sides which we are following, being those from Lough Foyle to Bengore Head, and from Bengore Head to Belfast.

In the section above indicated we find the following rocks exposed from above, downwards :—

(*f*) Tertiary Basalt.
(*e*) Chalk.
(*d*) Upper Greensand.
(*c*) Rhætic and Lias.
(*b*) Trias.
(*a*) Palæozoic Rocks.

We see from this table that between the Lias and Upper Greensand there is a great break. No trace of the Oolitic Rocks, Lower Greensand, or Gault is found.

The Palæozoic Rocks consist of metamorphosed Silurian or Cambrian, Old Red Sandstone and Carboniferous Sandstone, with Coal-measures at Ballycastle. The metamorphosed rocks mostly consist of hard, red, green, grey and blue slates and grits, with bands of primary limestone ; no fossil remains have yet been found. The Old Red Sandstone, as seen near Cushendal, very much resembles the English type of that colour.

The Carboniferous Sandstone is a very white rough freestone, and is used for building purposes. It contains carboniferous fossils. The coal-workings under Fair Head are of great antiquity, but the coal is of little value. There is an interesting account of their first discovery in the Belfast Field Club Guide Book. The section at Fair Head is divided into three series, similar to those occurring in Ayrshire :—

1. Edge Coal Series, consisting of red and grey Sandstones, with seams of coal and ironstone.

2. Limestone Series, consisting of Calcareous Shale.

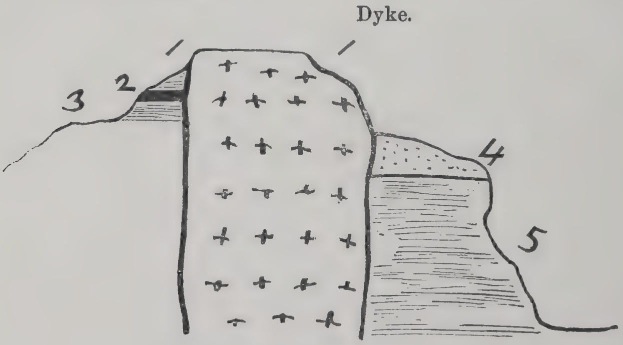
3. Cement Stone Group, consisting of red and yellow Sandstones, with shale and quartzose conglomerate at the base.

Here, as before referred to, the principal feature is the insignificance of the development of the limestone, which is elsewhere so well represented in Ireland. The coal-field runs from Fair Head to Ballycastle, a distance of some six miles, and the section is well exposed in the cliffs.

The Trias consists of red and green marls, unctious to the touch, sometimes hardened by intrusive dykes. The colouring matter is no doubt iron in the form of sesquioxide in the first case. These beds contain some bands of common salt, which is mined near Carrickfergus. The line of demarcation between the red and green colour is very sharp, the same hand specimens being parti-coloured. It is sometimes very difficult to distinguish the bluish-green marls from the Lias clay. The Trias is very nearly constant throughout the entire length of the section, being often of considerable thickness.

The Rhætic or "Avicula contorta" shales underlie the Lias, and are, generally speaking, the last to die out. Sections have been examined for a distance of twenty-four miles, from Lisburn to Whitehead. The bed is sometimes only one or two inches thick, but in Colin Glen it is nineteen feet, and at Waterloo fifty feet, its maximum development. The shales are often very much hardened, and sometimes contain bands of argillaceous limestone. Portlock long ago drew attention to the fact that there were certain strata linking the Liassic and Triassic formations.

Tate gives the following section of the occurrence of these beds in Cave Hill, near Belfast :—



1. **Upper Greensand.**
2. **Marly Shales, 8 ft. 10 ins.**
3. **Micaceous Sandstone, 2 ins.**
4. **Shales with "Cardium Rhæticum," 1 ft.**
5. **Indurated Shales, 1 ft. 3 in.**

The following fossils serve to indicate the age of these beds :—

Axinus cloacinus.
Cardium rhæticum,
Pacunopsis.
Pecten valonensis,

The Lias consists of the usual blue clay, stiff shales, and shelly, compact, blue or argillaceous limestones. There are also some oolitic limestone bands, which occur at Waterloo, and which were at first considered to be representatives of the Oolites, but which Mr. Tate has proved to be Lias.

The Lias is not constant, but is found in various patches along the coast. It does not appear to have been much folded before the the deposition of the Greensand, as both seem to dip together to the same extent. The junction of the Greensand and Lias is rarely or never seen, but there must be an unconformity, for there is only the lower members of the Jurassic rocks; and no Oolites, lower Greensand, or Gault.

The shales are indurated at Waterloo, indicating the first stage of metamorphism, they are changed into a so-called Hornblendic rock at Portrush, which so resembles the igneous rocks, that for a long time it was considered as such, until fossil remains were found in it. It was then contested that the igneous rocks were really of aqueous origin, since the igneous rocks contained impressions of marine organisms.

The Lias is altered by the heating action due to the basalt, and the various dykes which penetrate it. At Portrush the complete induration is due to the basalt, which here directly overlies the Lias ; this may be taken as representing the ultimate change.

Mr. Tate has described the occurrence of the following zones in the Lias :—

(*a*) Ammonites planorbis.
(*b*) Ammonites angulatus.
(*c*) ,, Bucklandi.
(*d*) Belemnites acutus (higher than A. Turneri.)
(*e*) Middle Lias Marls (Ballintoy.)

The Lias is underlain by the Avicula contorta shales ; he gives the following sections, which serve to indicate their appearance etc. at Waterloo.

(*a*) Avicula contorta beds are here a mass of indurated grey or brown marls ; they form the hill known as Banks Head, where they have a thickness of fifty feet, from which he computes their actual thickness at 120 feet ; they dip at an angle of 27°.

(*b*) Transition beds being white marls and black shales.

(*c*) Black indurated shales with A. planorbis.

(*d*) Sub-chrystalline fossiliferous limestone with A. angulatus.

(*e*) Compact blue argillaceous limestone with Gryphæa incurva, which he considers to represent the A. Bucklandi zone of England. It is exposed near the coastguard station.

(*f*) In the Belfast Museum are a few fossils which have been collected here, and which indicate the presence of the Belemnites acutus zone, but this zone is generally concealed.

The above section Mr. Tate considers should not only be regarded as typical for Ireland but also for Great Britain.

The angulatus zone which Tate considers to be identical with that of A. mercurius of the Côte D'Or, is the one which is most largely developed.

The planorbis zone occurs at Colin Glen, Whitehead, Glenarm, Waterloo, etc.

The angulatus zone occurs at Larne Lough, Waterloo, Glenarm, Tircriven Burn, etc.

The Bucklandi zone at Waterloo, Tircriven Burn, and Glynn.

The Belemnites acutus zone occurs at Ballintoy, Waterloo, and Carrickfergus. This zone is either parallel to, or newer than that of A. Turneri.

The Middle Lias Marls occur at Ballintoy. It will be seen from the above that only the Lower Lias is developed.

The cretaceous series consists of upper greensand and chalk limestone, which may be conveniently sub-divided as follows :—

(*a*) White limestone.

(*b*) Chloritic sandstones and sand, called "Mullato stone."

(*c*) Yellow sandstones and marls.

(*d*) Glauconitic marls.

The uppermost portions of (b) are often conglomeratic, pebbles of quartz being imbedded.

The Greensand contains many quartz pebbles, and some few phosphatic nodules, but never in sufficient number to make their collection profitable, it also contains siliceous nodules. The sand is sometimes quite red, sometimes yellow, and sometimes chloritic. When green, the colour is due to the presence of glauconite.

The Greensand is the most constant of the Mesozoic strata, having been found nearly everywhere along the whole line of section.

Everywhere, where the two can be compared, it seems to follow the dip of the Lias. It is sometimes hardened into a sandstone, consisting of the Glauconite and quartz grains imbedded in a cement of Calcium Carbonate, probably derived from the chalk. When indurated by an intrusive dyke there seems to be no chemical change, but merely a hardening.

Mr. Tate considers the Hibernian Greensand to belong to the étage cénomanien of D'Orbigny. The upper part of the formation is very intimately associated with the overlying chalk. Tate gives the following typical section at Woodburn river :—

(*a*) Glauconite Sands. These are dark green, consisting of Glauconite, with arenacious grains in a slightly argillaceous paste. This is the most persistent of the sub-divisions of the Upper Greensand. The fossil contents are chiefly confined to a bed characterised by the abundance of Exogyra conica, which bed occupies a median position in this sub-division, and forms a very good feature by means of which this sub-division may be traced. There are a few phosphate nodules in the lower bed. This zone has yielded thirty-six species mostly obtained from Whitehead during the construction of the railway. A few of them are named in the following list :—

Exogyra conica.
Pecten orbicularis.
,, Dutempleii.
Avicula lineata.
Pecten quinquecostatus.
Arca carinata.
Belemnites ultimus.
Ammonites varians.
Pecten virgatus.
Ditrupa deformis.

(*b*) Grey marls, yellow sandstones and chert. These contain few species and are limited in thickness; the heading gives their character. They are found at Woodburn River, Cave Hill, and Island Magee. Their characteristic fossils are :—

Ostrea carinata.
Vermicularia quinquecarinata.

Pecten quinquecostatus.
,, quadracostatus.
Rhynchonella latissima.
Ditrupa deformis.
Microbacia cardinia.

(*c*) Chloritic sands and sandstones. This is included under the head of what has been termed Mullato stone, owing to the fact that it is composed of partly sand and partly chalk. In the Woodburn Section, above described, there is some slight evidence of an unconformity existing between this and the underlying grey marls. These beds chiefly consist of siliceous sands in a calcareous paste, with disseminated chloritic grains, more and more compact higher in the series, until they finally pass up into limestone. Mr. Tate takes the Ananchytes ovatus bed as indicating the point where this deposit passes to the chalk, but the passage is so extremely gradual that no lithological line can be drawn. The fossils are :—

Inoceramus crispi.
Ostrea semiplana.
Terebratula obesa.
,, carnea.
Rhynchonella robusta.
,, latissima.
Pecten quinquecostatus.
Spondylus spinosus.
Heteropora cryptopera.
Catopygus carinatus.
Serpula filiformis.
Pleurotomaria perspectiva.
Cidaris vesicularis.
Epiaster distinctus.

On passing to the west from Woodburn river, this division becomes a siliceo-chloritic sandstone. These are the most fossiliferous sands, they are exposed at Black Mountain, Colin Glen, &c.

Mr. Tate describes it as an imperfectly bedded, white limestone, with splintry fracture and layers of flints. Beyond Colin Glen to the S.E. it rests directly on the red marls. Throughout the district described it is capped by flints imbedded in ochreous clay. These flints are bright red and encrusted with calcareous cement. Tate says the heat of the lava has oxidised the brown oxide of iron into the red oxide. Jukes does not agree with him on this point, though Barrois does. Jukes describes the basalt as containing lignite and iron bands. The flints, when broken, exhibit concretionary structure, varying from grey to red, as we pass from the centre to the outside, the covering of white being due to weathering after the red tints occurred. He describes a quarry where we have from the top :—

(1) Columnar basalt.
(2) Clay or lignite.
(3) Flint gravel, overlying the chalk with grey flints.

The workmen obtain stems of trees from the lignite, and the lignite contains 75.8 per cent. of volatile and combustible matter. Jukes says :—"How, if the basalt did not burn up the lignite, did it manage to redden the flints which underlie it?" Again, he says that the dykes only harden the chalk for a few feet on either side; the induration of the chalk is not due to the basalt.

The chalk bears great evidence of denudation, (1) in the hollows which occur at the top, and (2) in the quantity of flints which fill these hollows, which indicate that they are the accumulation derived from a great deposit of chalk, which has been carried away by water. They have also a very variable thickness, the deposit being 100 feet thick at Whitehead, and only a few feet at Colin Glen, while it is absent altogether in Woodburn river. At the base of the chalk there is a glauconite layer, indicating conditions like those existing when the Greensand was deposited. The chalk is covered generally with dendritic markings of Pyrolusite, it contains also some phosphate nodules, and curiously shaped flints called Paramoudras, similar to those found in England in the Belemnitella chalk.

Barrois says that in microscopic structure and chemical composition it is identical with that of England. The flints contain many minute organisms, sponge spicules, etc., forming a powder. These have been carefully examined by the Belfast Naturalists' Field Club.

The chalk is obtained for lime-burning, the basement beds being the best, as the lime formed from them sets more rapidly. It splits too easily along the planes of bedding to be used as a building stone. The chalk is nearly constant along the whole line of coast, though the thickness varies immensely. Near Dungiven, and from thence to Down Hill, it is only 20 to 30 feet thick. In Colin Glen it is also very poorly developed.

The chalk seems to have partaken of the same movements as the underlying beds down to the Palæozoic rocks, in fact the foldings all seem to have taken place in Tertiary times.

Mr. Tate concludes that the Irish chalk represents a high stage in the formation, certainly the Norwich, and probably even the Maestricht or yellow chalk, of the continent.

He divides the whole chalk into two divisions :—

(*a*) Chloritic Chalk, the basement beds being represented in the East by the bed of Ananchytes ovatus only.

(*b*) Upper Chalk also described as white limestone.

Mr. Tate calls his (*a*) Glauconitic Sands the zone of Exogyra conica or E. columba, in which thirty-six species occur, nineteen of which pass up into higher beds ; this he calls the equivalent of the Blackdown beds.

(*b*) The yellow sands or zone of Ostrea carinata, in which there are nineteen species, eight of which pass up, nine being present for the first time, he calls the equivalent of the Upper Greensand and Cénomanien of Normandy.

(*c*) The Chloritic Sands or zone of Inoceramus crispi contains seventy-eight species, ten of which occur in lower zones, nine only extending to the limestone. This, he says, is the equivalent of the Upper Greensand.

(*d*) The Upper Chalk he divides into three zones.

(1) Zone of Ananchytes gibbus.
(2) Spongarian zone.
(3) Ammonites Gallevilliensis zone.

He says that it represents the upper chalk of Norwich, Craie de Meuden, and some part of the Maestricht chalk.

M. Barrois sums up in his paper as follows :—

(*a*) The Glauconitic zone of Ostrea conica belongs to that of Pecten asper of the Warminster beds. It is very like the Holaster nodulosus of the N. E. of France.

(*b*) The yellow sands belong to that of Holaster subglobosus.

(*c*) The zone above this is Turonien.

He gives the following list of the fossils occurring in the Irish beds :—

	Cénomanien.	Turonien.	Senonien.
Terebratulina striata		*	*
Terebratula Hibernica		*	*
„ obesa	*		*
„ semiglobosa	*	*	*

	Cénomanien.	Turonien.	Senonien.
Rhynchonella robusta		*	
„ Cuvieri		*	*
Spondylus spinosus		*	*
Cidaris subvesicularis	*	*	
Ostrea columba ...	*	*	
„ semiplana	*	*	

He says he has never seen in Ireland representatives of the Danien, all belong to the Norwich chalk. The chloritic beds he considers to be of the micraster age. He divides the chalk proper into two zones. (1) Marsupites; (2) Belemnitella. He says that the fauna and characters are similar to those of their English equivalents. (2) is thirty metres thick ; (1) is 4-5 metres.

Comparison of the English and Irish Cretaceous.

IRELAND.	Metres.	ENGLAND.	FRANCE.
a. White Chalk with flints	20-30 ..	Belemnitella mucronata	
b. „ „ „	4- 5...	Marsupites	Senonien.
c. Chloritic Chalk ...	1- 2...	Micraster coranguinum ... „ cortestitudinarium	
d. „ Sand ...	1- 5...	Holaster planus ... ... Terebratulina gracilis ...	Turonien.
e. Yellow „ ...	1-10 ..	Holaster subglobosus ...	Cénomanien.
f. Glauconite „ ...	2- 3...	Pecten asper	

To account for the difference in character of the English and Irish faunas, M. Barrois supposes the latter to have been deposited in a shallow sea, proved by the glauconite bed and variable thickness.

The denudation has been less than in England, only the upper beds were deposited, which were protected by the overlying basalt, and hence have a greater development than in England.

The chalk is hardened or even converted into marble by dykes.

The basalt consists of augitic lava flows, it occurs in three different forms, 1, the columnar ; 2, the spheroidal; 3, the amorphous.

(1) The columnar consists of an aggregate of pillars, which may possess any number of sides from 4 up to about 12. They have the appearance of prismatic crystals, with the ends rounded into either a cup or a hemisphere. Each pillar consists of a collection of these prisms, each standing on the top of the other, the faces of the

prisms being continuous, so that when viewed from a distance, the pillar appears to consist of but one portion. It has been noticed that when there is a joint, the cup or the hemisphere does not extend right across the section at right angles to the prism, but that there is a small annulus surrounding the cup or hemisphere, which extends as a plane to the outside of the prism. Professor James Thompson, of Belfast has explained this in the following way :—When the basalt cools, it expands at the moment of solidification. The outside expands first and throws the interior into a state of tension ; the part thus thrown into tension gives way and forms the ball and cup. The outside of the pillar begins to weather until the basalt is of such a consistancy that on any slight movement the narrow rim of material still connecting the two joints snaps, and thus the annulus is formed. There seems to be no definite rule determining the occurrence of the cup and ball of the joints.

One portion included between two joints may have a cup at each end, a ball at each end, or a cup at one end and a ball at the other. In the pillars there seems to be no definite law connecting the relative position of these. We can have the cup of one portion uppermost, and a ball of the next one uppermost and so on. This follows from what has been said about the joints. Neither does there seem to be any law producing similar jointing in aggregates of adjoining pillars. The only generalisation which seems possible to be drawn is that, on examination of the separate flows, we find that the columnar jointing stops short some feet below the top of the floor, not taking into account the amount of basalt which may have been removed before the next outburst. The columnar formation has been supposed to be due to the fact that, in cooling, the basalt splits up into globules, each of which is surrounded and pressed upon by a certain number of others, thus giving it the shape of a many-sided prism. This theory does not account for the singular coincidence of so many joints one on top of the other.

(2) We find the basalt occurring in a form, which, on weathering, presents the appearance of an aggregation of spheroids cemented together by an ochreous-looking mud. These spheroids, when split open, present a concretionary appearance, as if they were formed of

sheet within sheet. This appearance is due to weathering which has proceeded in stages, from the surface towards the interior. They are often of a rusty colour, coloured by the hydrated sesquioxide of iron.

(3) The amorphous form is simply the ordinary form of basalt.

The basalt occurs in ranges one above the other, each range lying on amygdaloidal beds, often exhibiting rude lines of lamination or stratification.

Between these flows, lignite and iron ore occurs, the lignite representing the old forests which sprang up again and again, only to be devastated by the next flow. There appears to be no rule connecting the mode in which each consecutive lava flow is consolidated. First, one would be columnar, the next might be also columnar or spheroidal, or amorphous, and so on. It has been stated that this great volcanic outpouring was due to a gigantic fissure eruption, in which Mull participated, there has, however, not been one volcanic outburst, but many. As a rule the columns are either vertical or, in some cases where a dyke has pierced a previous outpouring, radiating at right angles to the dyke. In the amygdaloidal basalt many zeolites occur.

The lignite, which occurs in the basalt is of little use as fuel; the iron ore, however, is valuable, containing about 50 per cent. of oxide of iron, and a sufficient quantity of silicia to serve as a flux, in fact, it is sent to Glasgow to serve as a flux for other iron. It is due to the decomposition of the basalt, and occurs in horizontal sheets between the lava flows. It is now worked by a company at Larne, and exported in large quantities.

The basalt forms the capping of the whole plateau described, except where it has been cut by the rivers.

In some cases the foldings of the Mesozoic rocks are before, and in other cases after the lava flows.

The age of the flows is said to be miocene, as witnessed by the characters of the plant remains discovered and described in the lignite beds by Mr. Bailey in Ireland, and the Duke of Argyle in Mull. Mr. J. S. Gardner refers them to an earlier Tertiary age. How far the flows were confined to the miocene it is difficult to say, for they certainly occurred over a long period of time, for there are sometimes eight or nine flows superimposed, between each of which occurs a bed of lignite, showing that between each flow sufficient time elapsed for vegetation to spring up, and soil to accumulate to a considerable depth.

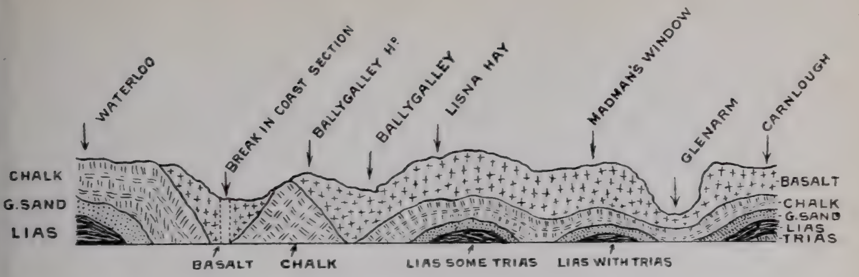
There are various post-tertiary deposits along this coast with which we are not at present concerned.

The appended section will exhibit more clearly than a long verbal description the position of the various outcrops of the beds, already briefly described (the section is diagramatic). There is a fairly continuous outcrop of chalk round the whole plateau, but fossils are generally scarce except near Dungiven, to be mentioned hereafter.

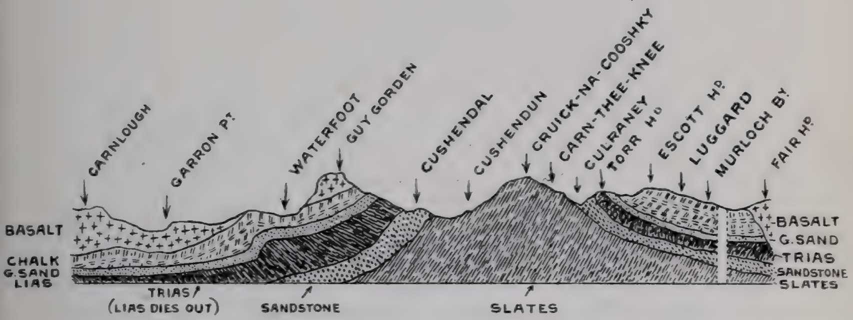
At Belfast there is a good exposure of the Lias and Greensand, about three miles out, along the Falls Road in Colin Glen. From Belfast, going west, there is the Lias and Greensand, near Carrickfergus, in the stream marked Woodburn river; then follows, still going west, Island Magee and Waterloo, the former by far the best fossil locality. Trias, Lias, and higher beds are alternately exposed in the shore till Cushendal is reached. Then follow the red sandstones, resembling the Old Red Sandstone, below which are the mica slates, which are not again lost till we pass Fair Head (see section); they are there capped by the carboniferous deposits already mentioned. Beyond Ballintoy there are the only representatives of the Middle Lias, a synclinal seems to have carried all, except the basalt, beneath the sea, to re-appear again near Portrush, where the basalt oversteps everything till it lies on the Lias, which it has converted into a kind of hornstone. Beyond Portrush (not shown in the section) the outcrop bends, and the newer deposits occur at a very high level, so that they are only exposed on the top of lofty mountains such as Benbradagh.

On the other side of Lough Foyle are the mica slates.

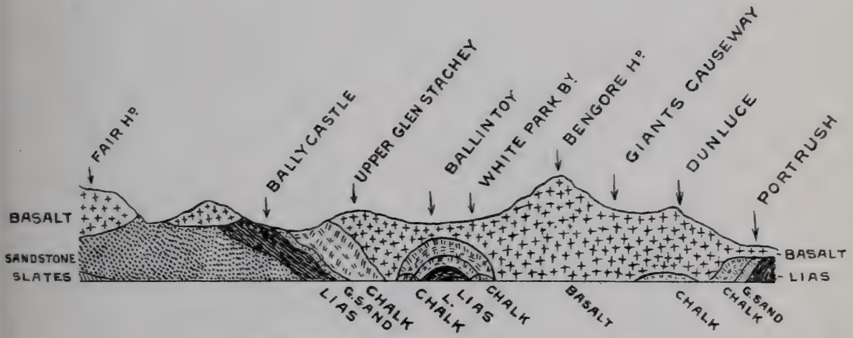
While on a geological tour round the north coast of Ireland last summer, I had occasion to visit a quarry at Dungiven, near Newton Limarady, situated at the top of Benbradagh, 1200 feet above sea level. Here the chalk is extremely fossiliferous. As this is the most westerly exposure, the list of fossils appended, named from the collection in the Woodwardian Museum, Cambridge, may be of some interest. The extreme abundance of Baculites seems indicative of a very high zone in the chalk, but the fossils found are not all such



WATERLOO - CARNLOUGH (14 MILES)



CARNLOUGH - FAIR HEAD (14 MILES)



FAIR HEAD - PORTRUSH (14 MILES)

VERTICAL-SCALE - 800 FEET = ½ INCH

HORIZONTAL " - 14 MILES = 3½ INCH

SECTION FROM WATERLOO TO PORTRUSH. N.E. IRELAND.

as would occur on the same horizon. The sponges, kindly named by Dr. J. G. Hinde, one of which is a new species, are also very abundant. As a rule the chalk was very unfossiliferous, so that the rich fauna found here is most noticeable. All the above specimens were obtained in the course of three-quarters of an hour.

	U. G. S.	Grey Chalk.	Chalk Marl.	Lower Chalk.	Middle Chalk.	Upper Chalk.	Senonien.	Maestricht.
Brachiopoda.								
Kingenia lima	*		*	*		*		
Rhynchonella octoplicata						*		
Lamellibranchiata.								
Pecten concentricus						*		
Cardium mailleanum ?								
Gasteropoda.								
Pleurotomaria perspectiva		*	*	*	*	*		
Turbo				*	*			
Rostellaria								
Turritella								
Littorina								
Cephalopoda.								
Nautilus lævigatus	*	*	*	*	*	*		
,, largilliertianus	*	*	*	*	*	*		
Hamites angustus?							*	
Scaphites.								
Baculites anceps ?								*
Ammonites gallivilliensis								
Belemnitella mucronata								
Echinodermata.								
Cidaris								
Discoidea cylindrica	*	*	*	*				
Echinocorys vulgaris					*	*		
Pisces.								
Otodus appendiculatus	*	*	*	*				
Cœlenterata.								
Parasimilia								
Spongida.								
Cœloptychium agaricoides						*		
Aphrocallytes spec. nov.						*		
Ventriculites infundibuliformis						*		

A MONOGRAPH OF YORKSHIRE CARBONIFEROUS AND PERMIAN POLYZOA.

PART I. BY GEORGE ROBERT VINE.

I.—Introduction.

A monograph of Yorkshire Carboniferous Polyzoa, will be, speaking generally, a monograph of nearly the whole of British species. There are a few forms found elsewhere, which, up to date, I have not detected in my Yorkshire material, but when we consider that only a few samples of our Yorkshire shales have been, as yet, persistently searched for the more minute fossils, we need not be surprised at that. Ordinary fossil collectors in the Limestone districts have secured many examples of *Fenestella* and *Polypora*, but the great mass of Carboniferous Polyzoa are small, and apparently insignificant, hence it is only those who study microscopic organisms who are brought into contact with the fragments found in shale washings.

If the whole of the species, however, are not found in the Yorkshire Limestones and Shales, the genera are, and to a large extent the *facies* of the Yorkshire species are peculiar, and thereby merit special recognition. Certainly on this head, I have done justice to Yorkshire examples in the pages of this Journal, but my previous work can only be regarded as a catalogue of the species, and not a monograph. In this higher sense a true monograph should embrace all previous work, and the description of the forms should be full and complete up to date, and the illustrations, superficial and structural, should also be ample. So far as I am aware no attempt has yet been made to give to the scientific world a monograph of British Carboniferous forms, and it is only just recently that monographs of American Carboniferous Polyzoa are being brought to the front by the Palæontologists of the various Geological Surveys. The forthcoming Report of the Geological Survey of Illinois will contain twenty-six plates of Carboniferous Polyzoa alone, besides seventeen plates of Devonian and Silurian forms, illustrative of species found in the varied strata of the same State. Most of the other papers which Mr. E. O. Ulrich will refer to in his noble work, must be regarded in a similar light with our own, as scattered fragments only, descriptive or otherwise, of a great and widely distributed Carboniferous fauna, and my desire will be to do for British Polyzoa what the late lamented Dr. Davidson did for the Brachiopoda, to furnish a full and reliable account of all the species known to me in our British rocks, but for the present I confine myself to Carboniferous and Permian Polyzoa.

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1854. ,, Brit. Palæozoic Foss. in the University of Cambridge.
1843-54. Morris, Prof. John : Catalogue of British Fossils ; Division Bryozoa.
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1873. Duncan, P. M. : On the Genus Palæocoryne and its affinities. Quart. Journ. Geol. Soc., vol. XXIX., p. 412.
1873. Etheridge, Robt. Jun. : The Genus Carinella. Geol. Mag. Dec. 1. Vol. X., p. 433.
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1875. ,, Note : Prov. Genus Carb. Polyzoa. Ann. Mag. Nat. Hist., vol. XV., p. 43.
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1874. Young, Prof. & J. Young : Notes on the Occurrence of Polypora tuberculata Prout.* Geol. Mag. Dec. ii., vol. I., p. 300.
1874. ,, On a New Genus Carb. Polyzoa. Ann. Mag. Nat. Hist. s. iv., vol. XIII., p. 335.
1874. ,, New Carb. Polyzoa. Quart. Journ. Geol. Soc., vol. XXX., p. 681.
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* See also Trans. Edinb. Geol. Soc. 1874.

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1878. ,, Two new sp. Carb. Polyzoa. Ibid, vol. iii., p. 354.
1877. Young, John: On Fixing Polyzoa; a new method. Ibid, vol. iii., p. 207.
1879. ,, Note, on Perfect Condition of Cell pores of Carb. Polyz. &c. Ibid., p. 211.
1880. ,, Note, Carb. sp. of Glauconome. Ibid, p. 257.
1881. ,, Note on the Genus Synocladia. Ibid, vol. iv., p. 30.
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1887. ,, Notes on Cystodictyonidæ Ulrich. Edinb. Geol. Soc., vol. v., p. 461.
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1878. ,, The Genus Fenestella, &c. Ibid, pp. 247 and 274.
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1884-5. ,, Polyzoa of Northumberland Shales. "Yorksh. Naturalist," pp. 61, 207 and 313.
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1881. Etheridge Robert : Anniversary Address Geol. Soc. Quart. Journ. Geol. Soc., vol. XXXVII, p. 171.
1878. Waters A. W. : Remarks on some Fenestellidæ. Trans. Geol. Soc., Manchester, vol. XIV.
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1886. ,, The above Collected and privately Printed.
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1881. , Further Notes, &c., Carb. Fenestella. Quart. Journ. Geol. Soc., vol. XXXVII., p. 178.
1882. ,, Thamniscus, Permian, Carb. and Silurian. Ibid, vol. XXXVIII, pp. 341-346.
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1849. King, Professor : Monogr. Permian Fossils, England. In which references to previous work will be found.
1861. Kirkby, J. W. : On Permian Rocks of South Yorkshire. Proc. Quart. Journ. Geol. Soc. "Polyzoa," p. 337.
1878. Etheridge, R. Jun. : Arctic Palæozoic Polyzoa. Quart. Journ. Geol. Soc The above important paper was compiled by R. Etheridge, Jun., and is taken from Manual and Instruc-

tions for the Arctic Expedition in 1875. In it the student will find a fair record of Foreign work on Carboniferous Polyzoa.

Beside the above separate articles there are brief lists of Carboniferous Polyzoa found in special localities, but I believe I have included in the Bibliography all the more important of these, or will do so in the section on Distribution after the descriptive text. Later on I will complete the Bibliography by giving a resume of American work on Carboniferous Bryozoa when the details come to hand.

III.—Terminology.

I. Zoarium, (= Polyzoarium). The composite structure formed by repeated gemmation.

II. Zoœcium, (= Cell). The chamber in which the polypide was lodged.

(*a*) Punctate, Cell wall ornamentation. (=" *Punctate*,") Busk and Hincks.

III. Cœnecium, (= Polypidom). Common dermal system of Colony.

IV. Ectocyst, (= Ectoderm). Outer layer of Cœnecium.

(*b*) Ectocystal tubes. Minute tubes which penetrate the Ectocyst.

(*c*) Interectocystal tubes. Tubes horizontal to Ectocyst.

V. Endocyst. Inner layer of Cœnecium.

VI. Funicular opening. Opening at the base of the Zoœcia for passage of Endosarc.

VII. Endosarchal passages. Openings between cell and cell.

VIII. Vesiculæ. Hollow, loose, or vesicular openings in the interspaces.

IX. Gonocyst. Inflation of surface or marginal extension of Zoarium.

X. Gonœcium. A modified Zoœcium set apart for reproductive functions.

XI. Operculæ. = Calcareous "closures" (Waters), superficial or otherwise by means of which the cells are closed. Function?

Class Polyzoa, Busk and Hincks.

= *Bryozoa* (part), Ehrenberg; Bryozoa (part) of American authors.

= *Bryozoa*, Hagenow; Reuss; Manzoni; Rœmer; Waters; Pergens, etc.

Sub-order CRYPTOSTOMATA, Vine.

1882. Cryptostomata. Abstracts. Proc. Geol. Soc., No. 424, (June), p. 109.
1882. ,, Geol. Mag., Dec. ii, vol. IX, p. 308.
1883. ,, Fourth Brit. Assoc. Rep., Foss. Polyzoa, p. 36 of Report.
1884. ,, Quart. Journ. Geol. Soc., vol. XL., p. 332, (1882 paper abridged).
1884. ,, "Naturalist," Yorksh., p. 65, et. seq.
1885. ,, Yoredale Polyzoa. Proc. Yorksh. Geol. and Polyt. Soc., vol. IX., p. 21.
1888. ,, Classification Palæozoic Polyzoa. Ibid, vol. XI., pp. 25 and 32.

Zoœcia tubular; slightly sub-tubular in section, or occasionally angular. *Orifice* of Zoœcia concealed; the true cell is surmounted by a large vestibule, in the throat of which is the restricted Zoœcial aperture. *Operculæ* calcareous, sometimes perforated in the centre.

Family CYSTODICTYONIDÆ, Ulrich.

1882. Arcanoporidæ, Vine. Abstracts and Proc. Geol. Soc., No. 424, p. 109. (June).
1882. ,, Geol. Mag. Dec. ii, vol. IX., pp. 381-382. (August).
1883. ,, Fourth Brit. Assoc. Rep. Foss. Polyz., p. 43 of Report.
1884. ,, Yorksh. "Naturalist," p. 65. Fam. suppressed.
1884. Cystodictyonidæ, Ulrich. Jour. Cinc. Soc. Nat. Hist., vol. VII., p. 34
1887. ,, Young. Edin. Geol. Soc. Jour., vol. V., pt. iii, p. 34.
1888. Arcanoporidæ, Vine, (History of,) Classification Palæozoic Polyzoa. Proc. Yorksh. Geol. and Polyt. Soc., vol. XI, pt. i, p. 27.

I have already given the history of Arcanoporidæ and Arcanopora in the paper cited above, and though the priority of my names are thus established, it may be well to state briefly my reasons for abandoning them. In the American Carboniferous rocks, the Polyzoa, though not perhaps more abundant as individuals, are more largely representative than in our own, and to me it would be a positive objection to have two names for one and the same group of organic forms. My desire is to present to the scientific student a monograph that shall be in accord with the latest and best American work, and I know full well that in Mr. E. O. Ulrich I shall find, in spite of differences of opinion on minor points, a co-worker rather than a mere disputant. The family name as given above, and the generic term *Cystodictya* may not be happy terms to me, seeing that I accept the Zoœcium and its character generally, as the basis of my classification, and not the Zoarium, but as I have been obliged to depart from hard and fast lines in some of my other groupings, it may be as well to give way here.

In founding the family name Cystodictyonidæ, Mr. Ulrich has indicated the genera that may be conveniently grouped together. They are *Cystodictya*, Ulrich ; *Coscinium*, Keyserling ; *Glyptopora*, Ulrich ; (= *Coscinium*, Prout) ; *Prismopora*, Hall ; and *Evactinopora*, Meek and Worthern ; and he suggests that probably other genera may ultimately be included in the Family. In our own Carboniferous Rocks we have not this wealth of generic forms, and in all probability only the following will find a resting-place here.

I. Cystodictya (Sulcoretepora) parallela, and raricosta.
II. Goniocladia cellulifera Eth. Jun.

Genus Cystodictya, Ulrich.

1829-36. Flustra ? Phillips. Geol. Yorkshire, p. 200.
1843-54. Sulcoretopora (pars) Morris and D'Orbigny.
1882-83. Arcanopora, Vine. 4th Brit. Assoc. Rep. Foss. Polyzoa.
1882-84. Cystodictya, Ulrich. Jour. Cincin. Soc. Nat. Hist.

Generic characters. Zoaria composed of two layers of cells : branches compressed, dividing dichotomously or at right angles, transverse section acutely elliptical, and sub-parallel, with sharp, non-poriferous margins. Zoœcia tubular (in section), superficially arranged in longitudinal series, from three to seven rows in the branch ; vestibular apertures round or oval, occasionally with a crescentic lip on the lower margin.

I have diagnosed the above genus with an eye to British, rather than to American examples, and I have adopted as much of Mr. Ulrich's description as would apply to these more particularly. The type species of the author is *C. occellata* Ul. Sub-Carboniferous Rocks, Kentucky.

I. Cystodictya parallela, Phillips. Pl. iii., figs. 1-13, pl. iv., figs. 18-26.

1836. Flustra ? parallela, Phillips. Geol. of Yorkshire, p. 200, pl. i., figs. 47, 48.

1844. Vincularia parallela, M'Coy. Carb. Foss. Ireland.

1854. Sulcoretopora parallela, D'Orb. Morris's Cat. Brit. Foss.

1880. Ptilodictya (?) parallela, Vine. (= Stictopora ? Hall). First Rep. Brit. Assoc. Carb. Polyzoa

1883. Arcanopora parallela, Vine. Fourth Brit. Assoc. Rep. Foss. Polyzoa.

1884. Cystodictya parallela, Vine. Naturalist, Yorkshire, p. 65.

1884. ,, Vine. Proc. Yorkshire Geol. Soc., vol. IX., p. 26.

1884. ,, Ulrich. Jour. Cincin. Soc. Nat. Hist., pp. 36-38, vol. VII.

1887-8. ,, Young. Jour. Edinb. Geol. Soc., p. 402, vol. v, pt. iii.

Specific characters. *Zoarium* calcareous, composed of thin flattened sub-parallel branches, having two layers of cells, but without dividing laminæ. *Branches* linear, occasionally dichotomous, bearing from three to seven rows of round or oval vestibular openings in furrows ; each row separated by apparently solid bars, excepting those near to the edges of the fronds or branches ; margins non-poriferous and striated. *Zoœciæ* semitubular, or slightly pyriform in section, but rarely exposed superficially ; orifices of Zoœcia concealed ; vestibular openings oval or round, frequently with a granulated peristome, lower edge of peristome occasionally crescentic and produced ; dividing ridges or bars also granulated ; three of these openings occupy the space of about 1-20th of an inch in length. *Gonocyst*, an inflation of the surface, or margins of the Zoarium. *Operculæ* (*?*)

Distribution. Yorkshire : Type sp., Phillips, Whitwell, Hurst and Richmond. Derbyshire : Castleton. North Wales : Halken, (rare). Lancashire : Holker Park, Gleaston. Northumberland : Redesdale, Fourstones. Scotland : Several localities. America : Sub-Carb. Rocks. (Ulrich).

This peculiar Carboniferous Polyzoon appears to me to be a survival of the Stictoporidæ group so prevalent, as individuals at least, in the early Silurian rocks of America. Further on I shall give ample illustrations of the minute external and internal structural features of this and allied forms.

Cystodictya parallela is met with in small fragments both in Yorkshire and Derbyshire, and still more minute fragments in Wales. In Lancashire and Northumberland the examples of the species vary very much, and I have fragments with from three to seven rows of zoœcia in the branch, but I do not see any material difference so far as facial or structural characters are concerned in any of the British examples of the species, except in a few fragments found in North Lancashire. In some of these examples there are wavy instead of straight bars, (Fig. 19, p. ii), but whether they should be placed as a variety of *C. parallela*, or otherwise my material is not abundant enough to decide. In Scotland *C. parallela* "occurs in both the eastern and western districts in the limestone strata of our coal-fields, but chiefly in the Lower Limestone shales. At Auchenskeoch quarry, near Dalry, Ayrshire, it is sometimes met with in linear fronds varying from two to three inches in length."* Mr. Young makes no mention of the mode (if any) of branching of the "linear fronds," and Phillips (Geol. Yorks. p. 200) says :—"No sign of ramification."

CYSTODICTYA RARICOSTA, M'Coy.

1844. Vincularia raricosta, M'Coy. Carb. Foss. Ireland, p. 198, pl. xxvii., f. 11.

1854. Sulcoretepora raricosta, M'Coy. Morris's Cat. Brit. Foss.

Specific characters. Elongate, parallel sides, section elliptical most convex on the porous side ; poriferous face convex, marked with fine sharp parallel keels, enclosing between them four rows of pores. Pores round, or slightly oval, with permanent margins placed twice their diameter apart, but irregularly with regard to each other. Reverse flattened, faintly marked with exceedingly fine, numerous, waving striæ, sides indented each by a prominent row of pores. . . . The species is distinguished from *Cystodictya* (Flustra) *parallela* Phillips, by having pores in the lateral furrows.

The above is M'Coy's description, and it very fairly indicates the superficial characters of this peculiar form, judging from the Scotch examples supplied to me by Mr. Young, but English examples are rare. In the Yorkshire shales only a few poor compressed fragments have, as yet, been found. In the Lancashire shales, small, narrow fragments bearing two, three, and four rows of cells between parallel bars, are more frequent, but even these I should be inclined to place as younger branches of *C. parallela*, rather than as examples of *C. raricosta.*

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* John Young, (Bibliog.), 1887, see ante.

Distribution. Ireland; Type species (M'Coy) Dungannon. Yorkshire: Hurst (rare). Lancashire? Holker Park. Scotland, in many localities, and "more abundant than C. parallela" (J. Young).

Genus GONIOCLADIA Eth. Jun.

1873. Carinella, Eth. Jun. Geol. Mag., vol. x, p. 433, pl. xv.
1873. ,, Eth. Jun. Descriptive Text, Sheet 23. Scotch Geol. Survey.
1876. Goniocladia, Eth. Jun. "Carinella pre-occupied." Geol. Mag. Dec. ii., vol. III., p. 522.

GONIOCLADIA CELLULIFERA, Eth. Jun.. pl. iv., figs. 14-16.

Generic and Specific characters. Zoarium composed of angular irregularly disposed anastomising branches, strongly carinated on both the obverse and reverse faces, but celluliferous only on the former, apparently arising from a common root. No regular distinction into interstices and dissepiments, but the branches bifurcate and reunite to form hexagonal, pentagonal, and polygonal interspaces or fenestrules, often of most irregular form. On either side the keel on the celluliferous or obverse face, are three, sometimes four alternating rows of cell apertures. The prominent keel follows each bifurcation of the angular ramifications, which are all celluliferous, no separation into interstices and dissepiments being apparent. The cell apertures have prominent margins; the reverse is longitudinally striate, and the keel does not appear to be quite as strong as on the obverse face.

Type and only species from Carb. beds, Carluke, Scotland.

GONOCYST, pl. iv., figs. 15 and 16.

As my English examples of this species are poor and fragmentary, it would be folly to alter, in any way, the diagnosis of Mr. Robert Etheridge as given above. In his remarks on the affinities of the Genus (Bibliog. ante, 1873, p. 101), the author says, "*Carinella* agrees with *Polypora,* M'Coy, in always having more than two rows of cellules on the celluliferous aspect, but it differs from Polypora in possessing a keel." A reference to the Yorkshire example (fig. 17, pl. ii.) will show the justness of this remark. There is a close affinity of this with that of Hall's Genus *Prismopora*, or rather with the Carboniferous species found in the Lower Carboniferous Rocks of Kakaskia and Tateville. U. S. Am. In the Scotch beds the size of the branches vary so much, that certain forms may be conveniently characterised as a variety of Etheridge's more delicate species. In the Yorkshire shales there is a still greater difference when fragments are drawn to scale. For convenience, therefore, I think it will be best to give a varietal name to one of the Yorkshire forms.

GONIOCLADIA CELLULIFERA, Eth. Jun.
var. robusta, pl. iv., fig. 17.

The fragments of this variety are similar to the above, only the branches are more compressed, robust, and the distances between the Zoœcial apertures greater. In pl. ii., (fig. 14), an example of the more delicate species, as found at Hurst is given, which when compared with the example, (fig. 15), from Gare Scotland very little difference is observable in the size of the branches. Fig. 17, however, illustrates the robust character of the form depicted. All are magnified about 30 times.

Distribution. Scotland : Type sp., (Eth. Jun.), Braidwood Carluke. The species is found in several other localities. Yorkshire : Hurst and Richmond, *forma* robusta, Vine, Hurst. In my Northumberland and North Lancanshire material minute fragments have been detected, but are very rare, and besides those named I have not found it in any other English locality.

MINUTE STRUCTURES OF CYSTODICTYA AND GONIOCLADIA.

In dealing with the minute structures of our British CYSTODICTYONIDÆ, I shall depend, more particularly, on my own investigations, rather than on those of others. At the same time it would be unwise as well as unjust to the authors, if I did not refer to two special papers on the same subject. In founding the family Mr. Ulrich says :—"In the proposed family *Cystodictyonidæ* we have a combination of characters not occurring in any other group, while on the other hand, not one of these can be said to pertain to this group alone, nor to be especially distinctive."* After going over the details of structure indicated by Mr. Ulrich in his American examples of the Family and Genus, Mr. John Young remarks (Bibliog. 1887. ante, p. 464) :—"The chief character, however, that distinguishes the organisms noticed in this paper, *(Cystodictya parallela* and *raricosta, Goniocladia cellulifera,* and *Hyphasmapora Baskii),* is in their having the interstitial spaces between the cells filled with small vesicular tissue, or curved cells, a character not generally known to exist amongst undoubted forms of the Polyzoa."

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* **Journ. Cin. Soc. Nat. Hist., vol. vii., p. 35, 1884.**

I. Superficial characters of *Cystodictya parallela*, Phillips, sp.

In describing the above species I have already referred to its facial features. Generally speaking, only small fragments are found in the Yorkshire shales, and in other localities, even the best, it is rare to find examples more than half-an-inch in length. The specimens given by Phillips in the Geol. of Yorkshire, are of fairish dimensions, and Mr. Young, as already quoted, speaks of fragments from two to three inches in length. In pl. ii., figs. 20 to 23, I have depicted several modes of branching in this species, from fragments in my possession, and as neither Phillips nor Young allude to "ramifications," these will be so far interesting.

II. Zoarium in section. I have already directed attention to the minute structure of the Zoarium of *Stictopora* ? (Ptilodictya) *lonsdalei*, Vine 1883-4, Biblio. ante. p. 37, and furnished ample illustrations of the same. In dealing with the structures of *C. parallela* I shall work along the same lines but with rather greater fullness. Whenever fair examples of this species are sectioned, we find, as already quoted a most peculiar combination of characters, both in the cells and Zoarium, not met with in the Silurian Stictoporidæ group. In the first place the laminar axis in *Cystodictya* is altogether wanting, or replaced by a basal attachment of cell to cell in a zigzag form, both in the transverse (pl. i., f. 12 and 13), and longitudinal direction (pl. i.. f. 3). In *Stictopora? lonsdalia* the so-called "laminar axis" is straight both in the longitudinal and transverse section. The "tubular" cells, also, are different in both species, and these, separately, may be regarded as characteristic of the two types of cell structure in some of the allies of both species found in Carboniferous and Silurian horizons, in this country and in America. There is, however, a faint similarity in the bars, and also in sections of the margins of the Zoaria, but beyond this there is no noticeable feature common to the two types. In the transverse section of *C. parallela* (figs. 12, 13, pl. i.) the opposite leaves fit into one another V shape, but the bases of the cells do not touch the neighbouring cells, for, as indicated in the sketch, a delicate interspace intervenes between them. These spaces it will be convenient to call "Endosarcal passages." The position which the superficial bars occupy in the Zoarium is in a line with the cells. The bars are, below a certain depth, structureless, and it appears to me that they are simply a calcification of the Ectocyst, which, as in recent species of Polyzoa, have been derived from the Endocyst of other cells. In the margins of the Zoarium the formation of the newer Zoœcia may be detected in all stages of development, produced by repeated gemmation, and I believe that to a large extent the vesicular character of the interspaces and margins of Cystodictya are really sections of newer, or the calcified remains of cells in process of formation. If so, then we have no *Cœlenterate* character to deal with in these older Polyzoa, but rather characters that are new to us probably, but nevertheless explainable if the Cœnecium of recent species of Polyzoa be studied and compared. On this head, however, Mr. Ulrich very justly remarks, "Tangential sections passing through the 'immature' region of the Zoarium show that the Zoœcia are ranged in longitudinal series between vertical plates, to one of which (see figs. 4, 5, 6, pl. i.) they are latterally attached, while the intervening spaces are occupied by irregularly shaped smaller cells. Nearer the surface the latter are no longer to be determined, being here filled by a secondary deposit."* In transparent portions of recent *Flustra* and *Carbasea*, better in the last-named, the cœnecium is best studied on the margins of the Zoarium, and here I find, that though newer cells are in processes of formation, by gemmation of course, in none of the partly-formed ones are there any indications of polypides until after a certain stage is passed. In the growing branches of *Zoobotryon pellucida* Ehrenb. the cœnecium may be studied far more advantageously, if the specimens be mounted in glycerine, and the action of the Endocyst, in the formation of buds and Zooids, conveniently traced. And I infer from these studies, without going into special details, that similar actions took place in the formal development of the Zoœcium, the polypide, and the colony of the species of Polyzoa found in our Palæozoic Rocks. Mr. Hincks, speaking of the "specific functions" of the Endocyst, after quoting Joliet's views says that the French biologist "regards the Endocyst as specially charged with the enlargement of the colony, and also as giving origin to a distinct tissue, which he names (provisionally) the *Endosarc*. . . . . ."* I do not say that I have read aright all the characters in these Palæozoic forms, but I have endeavoured, both by descriptions and illustrations, to help others in the pleasant, but by no means, easy work, of tracing out and identifying fossil calcareous structures.

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* Jour. Cincin. Soc. Nat. Hist. 1884 (op. cit.) pp. 35-36.

Gonocysts. So far as I am aware, this is the first time that the reproductive cells of Palæozoic Polyzoa have been figured, or I believe referred to specifically. In his Introduction to his British Marine Polyzoa (pp. ii. and iii.), Mr. Hincks furnishes a very fair and somewhat full chapter on "Terminology." In the introductory part of the present paper, I have adopted parts of this chapter for working purposes. As regards the ovarian cells of the Cheilostomata, much detailed information may be found in two papers by Mr. Hincks,† and a rather full list given of species in which the ovicells can be conveniently studied. But in the above work the Oœcium (= ovicells auctt.), is defined as a "special receptical, attached to the Zoœcium, in which the ova complete their development into the larva," but "the direct passage of the ova into the Oœcium has not been witnessed, nor have we, I believe, any observations showing by what means it is effected," (Op. cit., p. xciii.) As regards the history of the Gonocysts and *Gonœcium* we know but little, but their full definitions as given by Mr. Hincks, will be useful in the present division of my subject, so I shall not scruple in quoting them here. The Gonocyst is defined as an inflation of the Zoarium in which embryos are developed, while the Gonœcium is a modified Zoœcium only, set aside for reproductive functions. In *Crisia* we have good examples of the latter, while in the inflated surfaces of *Hornera* we have examples of the Gonocyst. In *Idmonea*, but very few species have been referred to or described having Gonocysts, but in several species of Diastopora, both fossil and recent the modified cells are common. "The Gonocyst has only been noticed in certain Cyclostomatous genera, it is probably only a modification of the Gonœcium. Of the history of these structures, however, we know little, they remain to stimulate and reward further research."*

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* Brit. Marine Polyzoa. Introduction p. xii.

† Note on Ovicells, &c., Quart. Journ. Micro. Soc., 1861; and on "Germ Capsules,' Ibid, n.s., vol. xiii.

I am not certain whether I should call all the structures now to be referred to, Gonocysts, but after quoting the above passage from Mr. Hincks, the student will be furnished with an authoritative opinion concerning them. In plate iii., figs. 10 and 11, I have given an example, unique in some respects, of a Gonocyst of *Cystodictya parallela*, Phill., or what I regard as such. In fig. 10, a portion of the Zoarium is enlarged for the purpose of showing its exact position on the side or margin of the frond. The same is enlarged about 60 diameters in fig. 11, and drawn with camera lucida, by which means details of structure are also given. Originally the Gonocyst appeared, that is before it was sectioned, as a roundish tubercle on the edge, partly covering a portion of the striated margin of the specimen. In the section, which has been carefully worked so as to get near the centre, the Gonocyst appears to have been formed under the ectocyst of the Cœnecium, and consists of a vesiculate chamber having a nearly circular opening. On the inner side it is attached to, and forms part of the marginal vesiculate edge, while just beyond it are the oblong bases of the cells up to the first bar. In plate iv, figs. 15 and 16, the Gonocyst of *Goniocladia cellulifera*, Eth. Jun., is given by way of comparison. The structure is of a similar character with that of *C. parallela*, but the difference is sufficiently noticeable to indicate that we are dealing with different species, but the family likeness is at once apparent. In plate iv., figs. 18 and 26, there are two examples of Gonocysts given, one figured and enlarged about 30 times, as a rather long excrescence on the margin, having a small orifice towards the top (f. 18), while in the other (f. 26), we appear to have a true gonecium, rather than gonocyst, formed in the angle of a dichotomised branch of *Cystodictya parallela*. I have two or three other examples of this form of Gonœcium, but the specimens are very rare, and what I have got are pickings from hundreds of fragments.

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* **Brit. Mar. Polyzoa, p. xcvi.**

In figures 24 and 25 two characteristic examples of "growths" on the Zoaria of *Cystodictya parallela* are given. In figure 25 the growth arises from the middle of the Zoarium and is drawn slightly sideways, and not artistically on the flat, for the purpose of showing its relation to the Zoarium. I have other examples of a similar growth to this one, and one fragment of *Cystodictya* from which the "excrescence" has been broken, and a shallow pit is all that is left on the Zoarium to indicate its former place. In a section, however, of a similar broken base (fig. 27) small vesicular openings mark the character of the bases of the excrescence. In fig. 24 the excrescence is marginal and of the character shown. I am not certain, however, that I should be justified in calling these Gonocysts, but in a certain sense they are reproductive, for from some, if not from all these excrescences, newer branches originate. Various excrescences are found in the Wenlock Shales, adherent to Polyzoa and corals alike, and Mr. Ulrich has found and described species somewhat similar to our own, in the Lower Silurian Rocks of America. These American forms are distingushed by the generic term *Crateripora*, Ul.,* and Mr. Ulrich describes several species, and remarks as follows :—"This genus includes several species, which occur in circular or expanded forms, presenting a minutely striated or pitted surface. Although I have examined a large number of good specimens, many of which were cut for examination with the microscope, we are not altogether certain that the genus should be referred to the sponges. It possesses characters entirely peculiar, and probably is a true Palæozoic type." That this may be the ultimate destination of some of the "excrescences" I have but little doubt, while others I can only regard as basal colonial growth of similar or dissimilar species.

A reference to plate iv., figs. 14 to 17, will be sufficient to prove that though the Zoarium of *Goniocladia* is different from that of

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* **Jour. Cinc. Soc. Nat. Hist., vol. ii., p. 29, pl. vii.**

Cystodictya, yet in the minute structures of the two, similar characteristic features prevail, such as vesiculæ between the cells and on the margins. In comparing these structures, however, with true Cœlenterate tissues I do not think that a similarity between them can be sustained ; yet at the same time I shall be happy to learn what the future opinions of others may be who take an opposite view.

EXPLANATION OF PLATES.

PLATE III.

Fig. 1. Fragment of *Cystodictya parallela*, from Castleton, Derbyshire.

Fig. 2. The same enlarged, showing superficial arrangements of *Zoœcia* in the branch, irregularly placed.

Fig. 3. Semi-transparent longitudinal section of Yorkshire example, showing peculiar zig-zag character of axis.

Fig. 4. Opaque section in which the edges of the Zoœcia are attached to the bar, right-hand side of branch.

Fig. 5. Transparent section enlarged about 60 dia. In this specimen the interspaces between the two cells are vesiculate, and the bars are seen to be triplicate. Inner part of the cells filled with calcareous matter.

Fig. 6. Two marginal Zoœcia, (right hand), in which the granulate character of the bars and cells are shown. Opaque, enlarged about 40 times.

Fig. 7. A single cell showing pear-like character of the aperture with vesiculate interspaces. Transparent mag. about 40 times.

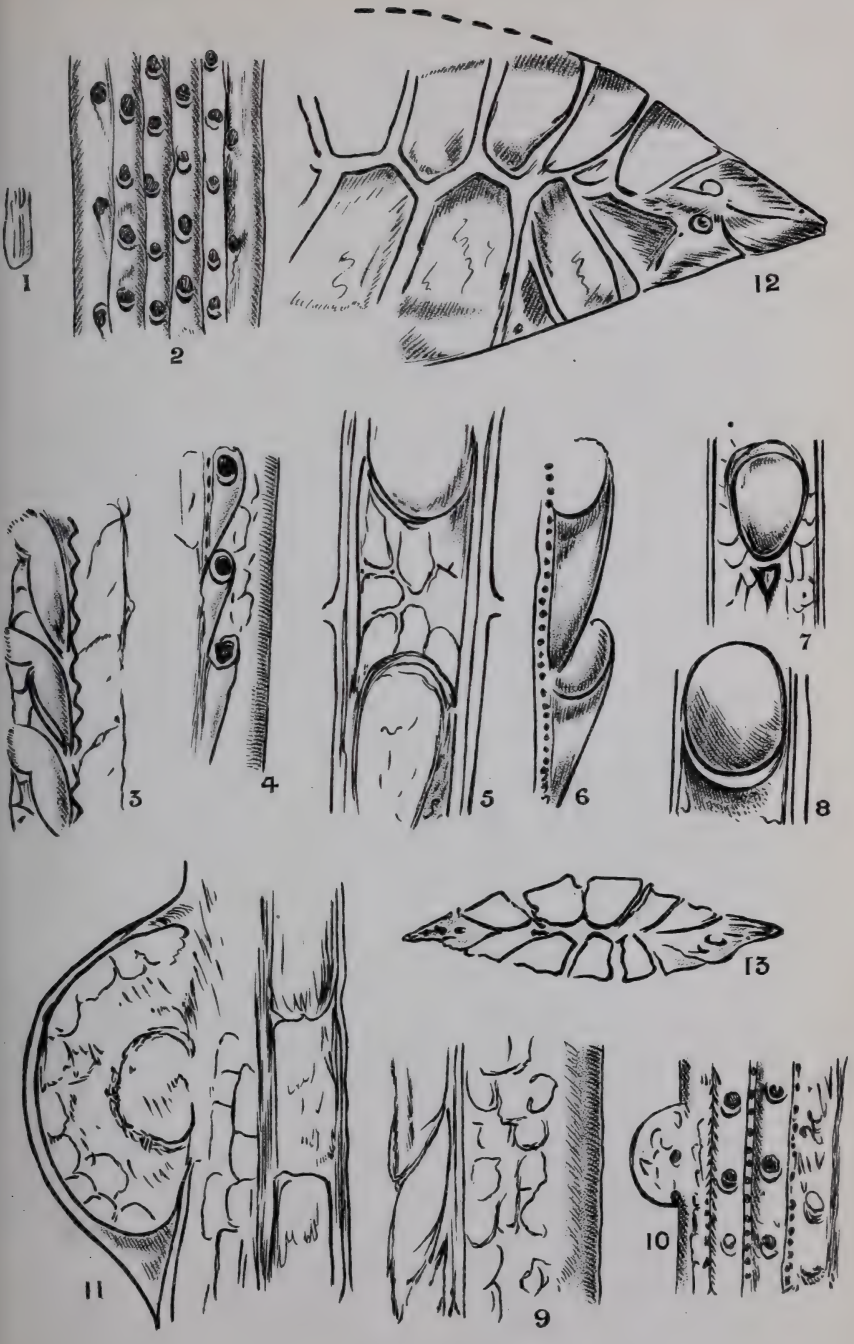
Fig. 8. Opaque ; outline of aperture of top cell in fig. 5 before it was sectioned.

Fig. 9. Transparent section showing the dense edge and the vesicula of the inner portion of the margin up to the first bar. Magnified about 50 times.

Fig. 10. Section (Hairmyres, Scotland), showing the position and general character of the Gonocyst, in relation to the other portion of the branch.

Fig. 11. Gonocyst and vesiculate margin, with oblong outlines of the bases of the three cells within the first bar of fig. 10. Magnified about 60 times. Drawn with camera lucida.

Fig. 12. Yorkshire example, transverse section, showing the general



VINE : POLYZOA.

character of the cell division of the leaves on either side of the branch of typical *Cystodictya* (Flustra ?) *parallela*, Phill. Mag. about 80 times.

Fig. 13. Section of another example not quite so transparent as above.

PLATE IV.

Fig. 14. *Goniocladia cellulifera*, Etheridge, Jun. One of the smaller examples of the species, Yorkshire ; opaque but cut through from the reverse side in a line with the axis. Magnified about 30 times.

Fig. 15. An example from Gare, (reverse side), not so deeply cut as the above, with rounded Gonocyst. Mag. about 30 diams.

Fig. 16. Gonocyst of No. 15 example, enlarged about 60 times.

Fig. 17. *G. cellulifera* forma *robusta*, Yorkshire. Flattened example magnified about 30 times, but slightly restored on the right hand margin. This is a true *Goniocladia*, otherwise the figure may be mistaken for a *Polypora*, as the Zœcia on the opposite side are similar to those shown in the figure. Reverse compressed. Keel very faint.

Fig. 18. Yorkshire example of *C. parallela*, showing marginal Gonocyst ; opaque view. As the example is unique, I am rather doubtful about its internal character. It differs from Scotch examples in some respects.

Fig. 19. *Cystodictya parallela*, or variety of same, from North Lancashire, in which the bars are wavy and finely tuberculated.

Fig. 20-23. Examples of *C. parallela* from different localities to show mode of branching.

Fig. 24-25. See text.

Fig, 26. Gonocyst in the angle of the branches. North Lancashire.

Fig. 27. Basal markings, see text on the Cœnecium of *C. parallela*. The two shaded parts are cells of the species to which the excrescence was attached.

ON THE RECENT EXPLORATION OF A CAVE AT ELBOLTON, NEAR THORPE.

BY REV. EDWARD JONES.

The Craven Naturalists' Society, in the ardency of youth, were desirous to add their quota of research into caves. We felt we knew but little, and that some practical investigation would help us, and perhaps be of use to more learned and experienced societies. Some of us, in rambling for fossils in the neighbourhood of Thorpe, heard of the existence of this Cave at Elbolton. It seems to have been often visited by the young farmers in the neighbourhood; they call it "Knavvy Noddle Hole." Whitaker, in his History of Craven, states that he went into a Cave near Thorpe, called Knave Hole Cave, and that there was a tradition that at one time it was a robbers' retreat. During Easter-week a few of the members of the Craven Naturalists' Society made a special visit to Thorpe to find this Cave.

Skirting the slopes of the grit moorland of Rylstone, Thorpe, and Burnsall Fells, there are a series of peculiar conical limestone hills, of which Elbolton, near to the hamlet of Thorpe, is one of the most prominent. The entrance of Knave Hole is at the foot of a small scar on the south side of Elbolton, about 100 feet from the summit. The present entrance is a pit-like mouth, and a ladder is required to make the descent in safety; the floor of the first chamber being about 20 feet below the mouth; this chamber is about 30 feet long, and varying from 7 feet to 13 feet in width; and with a height of nearly 40 feet at its further extremity. Here it narrows, and after a steep ascent of 18 feet, the cave continues in a narrow but lofty passage for 36 feet further. In this passage there is a perpendicular hole 12 feet in depth, and from the bottom of which, by a very low passage another small chamber is reached; none of our party however went into this further cave. In comparison with Dowkabottom and Clapham, Elbolton Cave appears to be small. The few stalactites, that within recent years hung from the top or adorned the sides, have been removed. The sides are damp, and covered with a beautiful white incrustation of carbonate of lime, more or less stalactitic, in some places soft, in others hard and crystalline. In the narrow upper passage there is a mass of stiff tenacious clay containing a quantity of angular particles of limestone and sand. At present there is no stream of water passing through the cave, though, after heavy rainfalls, water comes freely from the roof. It is evident that there are other openings to the cave as the roof must be near the surface, and there are two or three small pot-holes in the direction of the cave.

The floor of the first chamber consists of angular pieces of limestone, both large and small, together with stalactites interspersed with a small amount of clay. It is evident they have fallen from the roof and not been carried hither. We have not ascertained the thickness of this deposit. We think it will be at least eight feet. We pierced into this floor at a spot about ten feet from the entrance, and during the four visits we have made to the caves, an experimental trench across the chamber has been dug to the depth of about five feet. The character of this upper cave earth still continues the same ; the stones are all loose, though some of them are larger and freer from clay than the surface ones. So far we have found no rolled pebbles or foreign stones ; what seemed to be such have turned out when washed to be the curved parts of fallen Stalactites or Limestone Fossil Shells. In order to provide a zone between the undisturbed ground and the material thrown out of the trench, we placed newspapers on the floor upon which we piled the stuff from the trench. From the beginning the bones of animals were interspersed in the *débris.* Prof. Miall kindly determined a few bones and teeth I sent him after our first visit. Our collection of remains has since vastly accumulated, and we have had no opportunity of ascertaining fully their character.

Human remains of one or more individuals have been found at each visit. Last Wednesday, (Aug. 22nd, 1888), the lower jaw of an adult was exhumed, it is evident death has not been recent, as the strong and massive jaw has been sufficiently long in the ground to absorb much calcareous matter ; it is now much heavier than a recent one would be. The upper jaw, with portions of the skull, were found on the following Monday.

The exploration so far is but a preliminary one; we thought it desirable to get to the base of the upper cave-earth by cutting this trench, and as we have not reached that point, our report must be very incomplete; the deposit is geologically a recent one. The probability of coming to pre-glacial deposits with remains of older cave fauna, the cave bear, the mammoth and their associates is remote. Yet, there may be a possibility that those may have been entrapped and preserved even here, if this cave was an open one at that early period.

So far the exploration has been interesting, even in its negative results; we are unable to state that the cave was ever inhabited by man, and until yesterday I despaired of finding human workmanship. No celts or flints came to hand, not even a bare bodkin, I was going to say, when a loosened stone revealed two bone instruments that could have been used as bodkins; as to their true character, I leave that to those better informed. On carefully washing my treasures yesterday morning I found I had three pieces of early pottery, their inner sides are rough and black but the outer sides are smoother and brown, with ornamentation of diagonal lines intersecting one another. On the first visit, what seemed to be charred bones were found; they were put into a parcel, but the parcel was lost in the cave, and the fact of the bones being really charred cannot be ascertained.

Most likely the pots are portions of cooking vessels and a further search may bring to light the cooking-place, together with the usual pot boilers. Bones are scattered throughout the mass, most of them having been broken by fragments of roof falling on them, and some by man or ravenous beasts.

The list of the animals found in the trench is a tolerably large one, and subject to emendations and additions when the bones and teeth are properly examined, I offer the following as the list of animal remains obtained from Elbolton Cave:—Man, horse, ox, sheep, dog, fox, badger, pig, wild boar, red deer, rat, water rat, mouse, shrew, and three species of birds.

The thanks of the Craven Naturalists are specially due to Mr. Kelsall, the owner of the land, for permission to enter thereon and explore the cave.

Since this paper was read, the following interesting letter has been received from Mr. Jones :—

ROCKVILLE, EMBSAY, *October 29th, 1888.*

DEAR MR. DAVIS,

Since I wrote last to you I have visited the Cave on Elbolton two or three times. Once I went with Messrs. Hartley and Wilkinson, in an endeavour to explore the further chambers, and to take photographs of the interior. With great difficulty Mr. Hartley got into a small chamber at the bottom of the hole in the long passage, but further progress was barred by debris. The photographs were failures.

Then I had two miners with me for two days, working at the trench. The work was very difficult, and after reaching 9 feet from the old level we had to discontinue as we had nowhere to dispose of our material. We were still in similar stuff as at first, composed of angular fragments of limestone, pieces of stalactites most likely fallen from the roof, interspersed with bones, but no signs of a bottom, nor of rolled boulders or gravel. The next step that I think we shall have to take will be a thorough clearing out of the cave, by means of buckets and a roller at the mouth of the cave. The material can be more carefully examined at the surface than in the cave. The finds have been so far very interesting. We have proofs of a number of persons having died or been buried here. I have a large quantity of human remains, including three right femurs, which indicate three individuals. From negative testimony I think the bones are very old, as we have not found any object of metal, either ornament or tool. The only things that have yet turned up are the pieces of pot, all of rude workmanship, with two or three simple patterns, and the bone bodkins that you saw at your last visit. At the lowest point that we have reached we found a quantity of charcoal, with some charred bones and the skull of a little bird ; at this level the stones at the sides of the cave were cemented with stalagmite. In working towards the north end, about 4 feet from the surface, we came to about a square yard of hard flooring, that required the pickaxe to break it up. We found on it only a jaw of either a dog or wolf. In the clay near by a well-preserved human fibula was found. The miners said the floor had been "well puddled over" on the way to the further recesses of the cave. In the shaft of the cave I think there is also evidence of footholds for the dwellers to climb in and out of the hole.

I am, dear Sir, yours faithfully,

To James W. Davis. EDWARD JONES.

ON A LAKE-DWELLING RECENTLY DISCOVERED AT PRESTON (LETTER).

BY REV. E. MAULE COLE, M.A.

DEAR SIR,

A few years ago Mr. T. Boynton discovered a lake-dwelling at Ulrome, in Holderness, the first of the kind found in England. I have just had an opportunity of exploring the works, which have been for some time in progress, for diverting the course of the Ribble at Preston, in Lancashire, and constructing large docks in the marshes which border on the river course.

The excavations are at present at a standstill, and will probably remain so for a considerable time. The sections exposed, 30 feet deep, are extremely interesting. Every trace of boulder clay, which covers the Fylde elsewhere to a great depth, was ages ago removed by the river, and on the bared new red sandstone were deposited thick beds of gravel and sand, full of estuarine shells. In these gravels, at various depths, lie scores of huge blackened trunks of trees, with their ends mostly in the same direction—downstream. There is no trace of soil; they have all, without exception, been drifted into their present position, a position which does not appear to have been altered by any change in the river's course since the gravels were laid down.

Whilst tracing the line of trees I caught sight of some piles standing vertically in the gravel beds, and on closer examination found that they had been driven in to a depth of from 8 feet to 15 feet. The ends were roughly pointed. For a depth of 2 feet or 3 feet at the top a quantity of brushwood had been laid horizontally between the piles, so as to make a solid and firm floor. The length of the floor was about 17 yards, but I could not ascertain the width beyond seven yards, as evidently portions of the platform had been removed in the excavations. The appearance was exactly similar to the upper platform discovered by Mr. Boynton in Holderness, and I have little hesitation in assigning it to a lake-dwelling. The structure was erected in a marsh, distant about 100 yards from the present bed of the river. There were no traces of weapons or implements of any kind, but this may be accounted for by the fact that the navvies had no instructions, and no one in authority noticed what they were destroying. In the area of the unfinished dock, however, as I learn from the curator of the Preston Museum, the Rev. J. Shortt, no less than 52 pairs of antlers of the red deer have been found, 43 heads of the urus, 14 human skulls of the type found in our tumuli, two ancient canoes hollowed out of the trunks of trees, and a solitary bronze spearhead. No flint or pottery seems to have been discovered. Mr. Shortt has kindly promised to have the section photographed before the works are resumed; but it would be more satisfactory if the piles and brushwood could be carefully examined by competent persons, instead of being left to casual demolition. Doubtless there were many lake-dwellings once in this country, as in Switzerland, but so far, with one or two exceptions, they have escaped notice.

Wetwang, October 4. E. MAULE COLE.

ON THE INVESTIGATION OF BRITISH BARROWS NEAR HUNMANBY, IN THE EAST RIDING. (BRIDLINGTON GAZETTE, DEC. 8TH, 1888.)

The Rev. Canon Greenwell, whose labours for some years past in opening barrows in the North and East Riding of Yorkshire have aroused so much interest, has, for the last three or four weeks been engaged in opening a group consisting of five, situated on one of the highest and bleakest part of the Yorkshire Wolds, a few miles westward of Hunmanby and Filey, and about 600 feet above the sea level. The group referred to is on glebe land in the parish of Folkton, whose rector, the Rev. H. Blane, very kindly accorded the Canon permission to examine as he desired. Similar permission was also given to him by the Rev. Edward Mitford, of Hunmanby, and John W. Woodall

Esq., of Scarborough, in respect of barrows on the Flixton and Flotmanby Wolds, in the immediate vicinity. The Canon had the assistance of Mr. Walter K. Foster, of Leinster Gardens, Kensington, Mr. Thomas Boynton, of Bridlington Quay, and other gentlemen.

He commenced with barrow No. 1, the largest of the group, and locally known as "Sharp Howe." The mound forming this barrow was found to be eighty feet in diameter, and eight feet above the ordinary surface soil. It is known to have been six feet higher, and there was ample evidence to show that an attempt had been made at some time to open it out, but had not been proceeded with. The centre of the mound was found to consist of large pieces of pure chalk, covering an area thirty-seven feet in diameter. This was covered with a mixture of earth and chalk. At the base was found an encircling wall made of chalk, and three feet high. Below the cairn of chalk a grave was met with, oval in form, measuring 7½ by 5 feet, and penetrating to a depth of five feet into the chalk rock. Here was deposited a body, probably that of a woman, placed on the right side and in the customary contracted position, with the head towards the west, and the hands up to the face. The bones were much decayed, evidently through moisture, and some had altogether disappeared. Behind the feet was found a "food vessel" of the conventional form, roughly constructed, and ornamented by a diamond shaped pattern, produced by a twisted thong. The vessel was broken into many pieces, amongst which were mixed the probable contents when deposited. Further examination of this barrow did not result in any further discovery.

In barrow No. 2, a secondary interment was first met with, that of the body of a man laid on the right side in the usual contracted position. Behind the head was found a "food vessel" of somewhat better manufacture than the one already referred to, and having similar ornamentation. A large grave was found in the centre of the mound, but this had evidently been rifled on some previous occasion. The process of ploughing would ere long have destroyed all traces of the secondary interment.

Barrow No. 3, although the smallest, proved to be the most prolific in interments, all of which had been made in graves cut into the solid chalk rock to the depth of about 3 feet. Here, altogether, four graves were met with. In the first was found the body of a man in the usual position, and in front of the face was deposited a nicely chipped flint knife about two inches long. The second grave contained the body of, probably, a man, with the hands placed upon the knees, and upon the hands and knees was deposited a burnt body which to all appearance would have been interred at the same time. Immediately in contact with the front of the feet was a knife made from yellow flint and of about the same size as the one found in the first grave. The shape, however, was more oval and less pointed. In the third grave was also found the body of a man laid on its right side, the head to the west, and in a more than usually contracted position. The fourth grave contained another male body with a "food vessel" deposited in front of the face, of similar construction to the other graves. Behind the head were three rude scrapers of flint, and a small piece of unworked jet.

Barrow No. 4, measuring sixty feet in diameter and two feet in height, though much ploughed down was next dealt with. This barrow was constructed in a somewhat peculiar manner. A mound of earth, mixed with a little chalk had, apparently, been thrown up over the grave, in the first instance to the depth of about one foot. Upon this had been placed an additional mound mainly composed of chalk, but having some earth mixed with it. The mound was bounded by a carefully constructed wall one foot in height made of thin pieces of chalk laid horizontally. This encircling wall was not, however, complete, having a break $3\frac{1}{2}$ feet in width at a point due south of the centre, a not uncommon circumstance, as similar enclosing circles, and like this incomplete, have been met with in other sepulchral mounds. The additional mound had again been covered by earth and chalk, thus completing the construction of the barrow which was found to contain a large grave 8 feet by 5 feet, and 4 feet in depth, but which showed no signs of ever having been used for interment. It had never been disturbed and no trace of bones was visible; so that it would seem almost impossible to believe that any body could have been buried therein, and so entirely have disappeared. A similar absence of evidence of interment occurred in opening a very large barrow called "Willie Howe," about four miles distant from this one, where the presence of animal bones in quite a sound condition proved that a human body could not have been buried there, otherwise the bones would certainly have remained in evidence. A second burial was met with 25 feet east of the centre, namely that of a man laid on his right side, the head pointing to the south, and the hands placed in front of the chest. In front of the face was a "food vessel" of rude manufacture.

Barrow No. 5, next in size to that called "Sharp Howe," proved to have been dug into at the centre many years ago, when it would appear that an unburnt body had been found in the grave, which was 7½ feet by 4½ feet, and 2 feet deep, some remains of the bones having been left on the bottom. Two secondary interments of burnt bodies had not been interfered with. They were both insertions into an already existing mound. The cutting through the earth composing the barrow was distinctly visible. The first was placed 17 feet east of the centre in a circular hollow lined and covered with thin pieces of chalk. Among the burnt bones were a well-made oval flint knife and a pin made from the leg bone of a bird, having a hole through the broad end. Just outside the hollow and in contact with the covering stones of chalk was a well-made "food vessel" of an ordinary form, having four unpierced ears round the shoulder. The second burnt body was found at a point 7½ feet from the centre. It was contained in a circular hollow, which had a few chalk stones over it, cut into the already existing mound.

Having completed the examination of the Folkton group, Canon Greenwell next proceeded to open a large barrow about half a mile distant in a south-westerly direction, and this barrow was found to be 60 feet in diameter, and still, after much reduction through ploughing, 3 feet in height. It proved to be prolific of interments. The first met with was in a grave, 4 feet by 3 feet and 1½ feet deep, situated 13 feet east of the centre, and was found to be that of a child about three years of age, laid on its left side with the head to E.S.E. Close to the feet was a very beautifully ornamented and well-made "drinking cup." At the same distance, south-east of the centre, a second grave, 7½ by 2½ feet and 2½ feet deep, occurred.

This contained the skeleton of an aged man laid on the right side, the head towards the west, and the hands up to the face. At the knees were some bones of a pig, the remains of food deposited with the buried man. In a barrow about a mile distant from this, some bones of a pig were also found alongside two burnt bodies. Fifteen feet north of the centre, in an oval hollow sunk about six inches into the chalk, was a much crushed and decayed skeleton of a full-grown person, laid on the right side, the head being to the west. With this body were the remains of a child, some of the milk teeth being left. The bodies were covered with large flints, and the pressure of these on the bones had caused the broken condition in which they were found. Nine feet, N.N.W., from the centre another body had been buried in an oval hollow, 3 feet by 2¼ feet, made in the barrow one foot above the surface level of the ground. It had been lined with wood, a not very infrequent occurrence. The body, that of a man, was laid on the left side, the head to E.S.E., and the hands in front of the face. Behind the head was a "food vessel" of good form, ornamented in the upper part, yet rather rudely made. Fifteen feet east by south of the centre were many bones of a body which had been disturbed by the plough, to which was also due the partial destruction of a well-made "food vessel," which had been deposited at the time of burial. At the centre, and laid on the natural surface, was a skeleton which had been placed upon wood. It was on the right side, the head towards the north, and the hands up to the face. At the back of the head was a round flint scraper and two flint flakes Beneath the head was another flint flake, and in front of the face, between it and the knees, a very well-made flint knife and a large flake were found.

Another barrow, about 200 yards northward of the last, 60 feet in diameter, but now only 1½ feet high, was found to contain a single interment. This had been made at the centre, and the body laid on the left side in a slight hollow, made in the original surface and lined with wood. The head was to the N.E., and the bones were very much decayed. Before the face was a very fine "food vessel," most tastefully ornamented with fine lines forming a herring bone pattern, and having four unpierced ears at the shoulder, and at the rim a broad ear perforated. In front of the face were a long, narrow flint knife, carefully and minutely flaked, and a long and round scraper of flint. In this and the preceding barrow it will be observed that the primary interment had not, as is usual, been made in a grave, but placed on the original surface.

The last barrow opened was on Flotmanby Wold, and was seventy feet in diameter, 4 feet high, and made of earth with some flints. It was found to have been opened already at the centre, and from information gathered from the shepherd, a "pankin" had been found. At a distance of 4 feet from the centre, and 2½ feet above the surface level was an urn of the cinerary type, ornamented over the upper part with a diamond shaped pattern, made by the impression of a twisted thong. No bones, either burnt or unburnt, were found in association with it. In the material of this barrow there were a large number of flakes and chippings of flint, three cores, four scrapers, and two stones which had been used for pounding. With the opening of this barrow, Canon Greenwell brought his labours to a close, leaving several in the immediate neighbourhood to be opened on some future occasion. The total result of his "openings" this autumn has been exceedingly satisfactory, and it is the Canon's intention to forward the whole of the interesting articles herein described to the British Museum, thereby adding to the already large collection contributed by him to that institution during recent years.

ON THE OCCURRENCE OF A BOULDER OF GRANITOID GNEISS OR GNEISSOID GRANITE IN THE HALIFAX HARD BED COAL.

BY JAMES SPENCER.

From time to time during the last thirty years, boulders of quartzite and other hard rocks, having quite a distinct structure from that of any native rock of the district in which they occur, have been found in the coal beds. Many years ago, before the great importance of these boulders from coal beds was recognized, a fine specimen was found in the Hard Bed Coal at Dam Head Pit, in Shibden-dale, near Halifax. At that time having no means of submitting it to microscopic analysis, the most notable feature about it was its spherical and highly polished form. It was a hard white rock streaked with patches of darker hue, and of about the size of an orange; it had evidently been subjected to a great deal of attrition.

About the same time, my friend, Mr. George Lister, had a fine quartzite boulder brought to him which was found in the Low Moor (near Bradford) Better Bed Coal. It was about the size of an ordinary football, and he informs me that the boulders in this locality were not very rare.

Since that time boulders of quartzite and other rocks have been found in coal beds in various places in the Midland Coal-fields, and also in Lancashire and Derbyshire, some of which were described by Professor Bonney in his presidential address to the Geological Section of the British Association at Birmingham in 1886. In the spring of last year two or three quartzite boulders were recorded by Mr. C. Brownridge, F.G.S., from the Black Bed Coal at Leeds. Two of these were subsequently sent to the writer to cut and mount sections for examination under the microscope, and a thin slice of each specimen was sent by Mr. Brownridge to Professor Bonney for examination, and have already been described.*

In the spring of the present year, 1888, I was very fortunate in obtaining from Shibden Head Pit, near Halifax, a boulder of a most interesting character, which had recently been found in the Hard Bed Coal. The specimen is of a greyish colour, about four inches in length, by about two and a half square. The angles have been worn off, and the faces polished and striated transversely. The striæ are most probably due to slickensiding in the coal rather than to glaciation. After preparing thin slices for examination under the microscope, it was evident that the specimen presented a different structure from either of those recorded from the Black Bed Coal at Leeds. Upon receipt of a section of this boulder, Professor Bonney replied as follows:—"The boulder is one of unusual interest. It is not a quartzite but a granitoid gneiss or gneissoid granite, probably derived from some mass of pre-Cambrian age." "The specimen practically "consists of two minerals, quartz and felspar. The former occurs in

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"grains of irregular outline, sometimes associated, and often joined, "as it were sewn together, by microcrystalline quartz, which also "occasionally extends into small patches. Numerous small inclosures "give it a dusty look; many are empty cavities; some contain fluid. "The felspar also occurs in grains of roundish to rather irregular "outline also often associated. It is much decomposed, but some is "probably orthoclase, and microcline can be distinctly recognized. "Parts occasionally are blackened by clustered granules. Without "destroying the slide I cannot say whether these are iron oxide or "some carbonaceous material which has infiltered. As its presence "has no important significance I have thought it needless to ascertain "its precise nature, but believe it probably of secondary origin. "Rather roundish grains of quartz are occasionally included in the "felspar, as is common in old granitoid gneisses. I note a very little "flaky viridite. It is possible that the gneissoid structure is due to "mechanical deformation of a granite, but if so, reconsolidation has "been complete. The structure, in short, recalls a type of rock "which is exceedingly common among gneissoid rocks, which are "universally admitted to be much older than any part of the Cambrian, and which is, so far as my experience goes, exceedingly rare, "if not altogether wanting in any rock of Palæozoic or later date."

Considering the great interest attached to the discovery and examination of these boulders from coal seams, it may be important to point out some of the conditions attending the deposition of the strata enclosing the coal seam in which they occur, and also the general character of the strata, and the direction from whence they appear to have come. Dr. Sorby has well shown, by data derived from microscopic examination of the sandstones and grits of the lower part of the Coal Measures, that these rocks are composed of materials which were most probably derived from Scandinavia; and this conclusion is supported by the general trend of these strata, which is from north-east to south-west. The Coal Measures were deposited in a slowly sinking area, with occasional pauses or even slight elevations of the land above the sea level. The strata enclosing the Hard Bed Coal furnishes one of the most striking examples of these mutations of land and sea. A short distance below this coal there are three separate layers, chiefly composed of Anthracosia, indicating marine or estuarine deposits, while the Hard Bed Coal has been fully demonstrated by microscopic examination of the admirably preserved plants which occur in it, to be a land deposit. Immediately overlying the coal a bed of marine shells, Aviculopecten papyraceous, occurs, followed by some yards of strata containing Goniatites Listeri, and other marine shells. Here then we have evidence of great changes of level indicated in these strata, during which the currents bringing deposits may have varied considerably. But there may have been other changes of level having important bearings upon the formation of coal and other matters in connection with the deposition of strata, which have either left no traces behind or they are so obscure as to have hitherto escaped observation.

The boulder of Gneissoid Granite for instance, now under notice, was found in the midst of coal which was not disturbed, or in any way differently disposed from the rest of the coal bed. This may indicate a slight depression of the area so as to bring it within the influence of the tides, or the area may have been near a large estuary which was subject to occasional floods, during which the boulder may have been brought down on floating masses of vegetable matter, or entangled in the roots of a tree and deposited in the submerged area. That the area now occupied by the Hard Bed Coal was occasionally subject to incursions of the sea, or at least overwhelmed by water containing Carbonate of Lime in solution, is proved by the abundance of calcareous balls, containing coal-plants, found in the midst of the coal. It has been suggested that these far-travelled boulders, found in coal, may have been brought by icebergs, but this idea does not seem to be supported by the facts. So far as I could gather, and I happened to be on the pit-bank when the one under notice was brought out of the pit, this boulder was not accompanied by any other detritus such as sand or clay or smaller pebbles, which might reasonably have been expected had ice been the carrying agent; and such is the case I am informed wherever the boulders are met with in coal beds. It seems to me, therefore, more reasonable to attribute their transportation to drifting and tangled masses of vegetable matter rather than to ice.

It may be of interest to note the exact locality in which the boulder was found. It came from under the north side of a hill called Barehead, in Shibden-dale, about two miles north of Halifax. The round whitish boulder above-mentioned came from under the south side of the same hill, at a distance of about half a mile from the place where the present one was found. The Hard Bed at Shibden Head Pit is found at a depth of 450 feet from the surface, the geological horizon of that coal being about 200 feet above the Rough Rock, the uppermost member of the Millstone Grit series. In conclusion it may be useful to note that about 600 feet of strata, including the Northowram and Elland Flag Rock, intervene between the Hard Bed and the Better Bed Coals, while the Black Bed Coal lies 120 feet above the Better Bed Coal. The materials forming these strata appear to have come from the north-west. A knowledge of this, along with that of the structure of the boulders, may help to form some idea of the locality of the parent rock from whence the boulders were derived.

Professor Bonney detected a resemblance between the rounded grains in the quartzite from the Black Bed Coal and those in a specimen of quartzite from the Lickey Hills and from the Charnwood series, he, however, very guardedly remarked, "Of course I do not mean to suggest that we must look in this direction for the parent rock." If we may judge from the direction in which the materials forming the Millstone Grits, and the Lower Coal Measure Grits and Sandstones have come, it is not improbable that the Gneissoid granite under notice may have come from some pre-Cambrian rocks connected with, or Scottish outlier of, the Scandinavian mountains.

THE LAKE-DWELLINGS IN EAST YORKSHIRE.

BY JAMES W. DAVIS, F.S.A.

The consideration of phenomena which have a tendency to illumine the history or habits of the early inhabitants of this country must at all times be looked upon with a large amount of interest. From this point of view the discovery of the remains of a number of ancient Lake Dwellings in Holderness, the low-lying district between Hull and Bridlington affords a glimpse of the habits of a people who lived during ages of which there is no written history, and of whose existence there is no record but such as can be gathered from the remains of rude platforms built on the edge of a lake or mere, on which to erect dwellings affording a scanty shelter from the inclemency of the weather, some protection from the wild animals of the neighbourhood, or the attacks of their human but more dangerous foes. Living over the water they naturally found that the readiest method of disposing of the refuse was to throw it into the lake below : and so it happens, that in digging beneath the platform there are found, mixed with the natural accumulation of peat, large numbers of the bones of animals which had been used as food, charred wood from their fires, implements of stone used as adzes in shaping and pointing the piles, rounded stones for pounding and grinding corn, arrow and spear-heads, rudely-fashioned objects of bone used for fastening skins round the loins, or for personal adornment of the primeval inhabitants of our island, as well as other objects of less definite purpose.

Holderness occupies an area circumscribed by the chalk hills which extend from Flamborough Head to the Humber on the one side and the sea on the other. It is a low-lying district, the almost uniform flatness of which is but slightly relieved by little rounded hills of gravel. The central part, extending north and south, is in some instances below the level of the sea, whilst along the coast the ground rises, so that the drainage instead of seeking an outlet towards the sea runs inland and is emptied into the Humber. Formerly the lower levels of Holderness formed a series of plant-laden meres, connected by streams one with another, and ramifying in every direction.

These once characteristic semi-stagnant expanses of water have all been drained, and with the exception of Hornsea Mere, which is below the sea-level, the sites they occupied are only indicated by the names which the places still retain. It is with difficulty that the richly-cultivated and fertile plains of the Holderness of to-day can be conceived as a country full of swamps, bogs and lakes, almost impenetrable either on foot or by other means. The slightly higher ground was for the most part densely wooded, and much vegetation covered the whole of the country. It extended far out over the area now occupied by the North Sea. The rapidity with which the land has been washed away may be inferred from the fact that during some years as much as fifty feet have gone during one winter; and since the days of the Stuarts the sites of villages and churches which were considerably within the coast line, are now far out at sea.

> There rolls the deep where grew the tree.
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> The hills are shadows, and they flow
>   From form to form, and nothing stands;
>   They melt like mist, the solid lands,
> Like clouds they shape themselves and go.

The woods and higher ground were infested with wolves; and the wild boar grovelled in the slimy margin of the pools, rooting up succulent morsels from the luxuriant vegetation, thriving in the damp and vapour-laden atmosphere. The red-deer and the horse roamed in herds over the district, making incursions from the higher ground to the westward, and numerous small animals lurked in the recesses of the forest. It is probable that at this time the beaver had formed its wonderful habitation in the more rapid streams of the district, and unconsciously competed with its human neighbours in the stability and comfort of its water-protected home. Birds were common, the wild goose being so abundant that even to this day the higher ground in the vicinity of one of the lake-dwellings retains the name of Goose Island, though it is long since it was an island and the wild goose is a *rara avis* now.

It was on the edge of one of these semi-stagnant, reed-grown meres at Ulrome that Mr. Thomas Boynton discovered the remains of an ancient lake-dwelling. The edge of the lake was towards the east, and at no great distance was an island the surface of which at the present time is twenty-five feet above the sea-level. It was between the shore of the lake and this island, still named Goose Island, that the pile structure was placed. It consists at the base of a number of trunks of trees placed horizontally on the bottom of the lake, and held in position by rudely-pointed stakes. The largest timbers, twenty feet in length and eighteen inches in diameter, extend from east to west across the course of the stream, which appears to have run in a northerly direction. The direction of the flow of the water is indicated by the addition of diagonal piles placed to lean against the larger trunks, in order to prevent their being disturbed by floods or other circumstances causing more than the ordinary pressure. Between the large timbers, which were laid parallel to each other, with as great regularity as their rough unhewn surfaces allowed, shorter trunks were placed transversely, resulting in a rude but solid and compact framework. The whole, fastened in position by stakes, four to six feet in length, driven into the bottom of the lake, formed a rectangular platform thirty yards in length from east to west, and eighteen in breadth from north to south. At the south-east corner a pair of large timbers extend parallel with each other, about five feet apart, from the platform to the shore of the lake; they have been prepared with greater care than those used for the platform itself; the upper surface is hewn flat, and they have been carefully fixed in position, evidently to form a means of communication between the habitations and the adjoining land. The trunks and branches of trees are mostly oak, ash, birch, willow, and hazel. The interstices between the timbers of the platform were filled up to the top with broken wood and twigs until a level surface was obtained; this was covered with bark and sand. On the foundation thus securely formed, probably reaching a little above the surface of the water, were erected the dwellings of the builders.

The structure exposed during the excavations proved that the original platform, after the lapse of a considerable period of time, either subsided beneath the water, or for some other reason became untenable, and a second one was added. The newer or upper platform is arranged much in the same way as the lower one. The horizontal timbers of the superstructure are held in position by piles, which may be distinguished from the earlier ones by the long and sharp point, evidently cut by a sharp metal instrument. The points of the later piles are not unfrequently found piercing the timbers of the earlier stage, which may be taken as an indication that the latter were more or less decayed, and consequently had become depressed beneath the water, hence the reason for the erection of the second structure. The two platforms together are between four and five feet in thickness. The top of the upper one is four feet beneath the surface of the ground, the intervening strata consisting of three feet of peat immediately overlying the wooden platform, and a foot of warp and soil. Beneath the base of the lower platform the thickness varies with the position ; near the edge it rests on a bed of sand and gravel which forms the bottom of the old lake ; further out it is separated from the sand by an increasing thickness of peat. The gravel forming the bottom of the old lake is about ten feet beneath the present surface of the ground.

Amongst the sticks and bark filling up the interstices between the timbers of the lower dwelling a number of implements and some fragments of pottery have been found. The latter is dark-coloured and possesses all the characters of pottery made by the Celtic inhabitants of the country of the earliest period. The implements are made either of stone or bone, and consist of pointed or sharpened stones pierced in the middle for the introduction of a wooden handle, used as hammers ; picks and hammers are also made from the antlers of the red deer. The large leg-bones of oxen, broken diagonally midway between the two extremities, and pierced near the joint with a circular hole for the insertion of a stick, appear to have been used as hoes ; the diagonal fracture is more or less smoothed by use, and an implement of this form would serve very well to break up the light soil on the higher ground adjacent to the mere. Flint flakes, used as knives and for other purposes, such as cleaning the skins of animals, have been found. A large stone of oval form and coarse granitoid texture, with a flat smooth surface exceeding a foot in largest diameter, may have been used for grinding food, and other smaller rounded stones were apparently used for pounding grain.

Hazel nuts were numerous. In addition to the bones of animals already mentioned, there have been found the jaws of wolves, tusks of wild boars, portions of the head of red deer and horse, and the bones of sheep, dog, and smaller animals, as well as the bones of birds. They were mostly at a depth of about six feet below the surface, and four feet from the bottom of the lake.

Between the first and second platform a fine bronze spear-head was discovered. The occurrence of bronze, together with the form of the pointed piles, evidently cut by a metal instrument, naturally leads to the inference that the later platform was erected during the period usually termed the Bronze age. An approximate idea may be formed of its age if it be remembered that the knowledge of bronze was succeeded by that of iron ; of the latter metal there is no evidence in the lake-dwelling, but it was known to the people whom Julius Cæsar found occupying this country, and was probably in use for two or three centuries previously. It will be safe, therefore, to fix the date of the more recent portion of the pile structure not later than the second or third century B.C. The objects found beneath the lower platform indicate a much earlier period, when the use of bronze had not been discovered, and the articles and implements were made from either flint or bone ; the older structure is probably of the earlier portion of the later stone age. Its great antiquity is shown by the depth at which the objects already mentioned were found, and by the circumstance that the parts of the lake surrounding the pile-dwellings became filled up to a depth of four or five feet with peat, before the second platform was constructed. The Barmston and Skipsea Drain follows the course of what was undoubtedly, in prehistoric times, a chain of lakes extending from Skipsea to its present termination on the sea-shore. Along this line five or six other pile-structures have been found, in some instances considerably larger than the one explored at Ulrome. There is every probability that careful examination of the surrounding districts will disclose the fact that numerous other erections exist over a considerable area, and as each of the platforms afforded space for several dwellings, it is reasonable to suppose that the pile-dwellers were a somewhat numerous people. The great preponderance of implements useful for tilling the soil over those of warlike character seems to indicate that they were peaceably disposed, and inclined to agricultural pursuits ; they were acquainted with the use of pottery, which they shaped into rude vessels without the use of the potter's wheel, and decorated by making incisions, either with the finger-nail or a pointed flint, on the surface. The nodules of flint, which occur abundantly in the neighbouring chalk, chipped into the form of an arrow-head, spear-head, and such other objects as they had skill to make or comprehension to use, served them for offensive and defensive purposes. The antlers of the red deer and the humerus of the ox, broken diagonally, probably assisted in breaking up and tilling the soil.* The harder bones of animals were scraped and carved into the form of pins and other implements for personal use and adornment.

Tolerably safe from the attacks of wild animals, which prowled in the neighbouring woods, when in their habitations over the water, this hardy people protected themselves from the chill east winds which swept over the North Sea, as best they could, with the skins of wild animals caught in the chase, or killed for food. It may be desirable to consider the relationship of the pile-dwellers to the population existing in the adjacent parts of the country at the time the dwellings were erected. The objects found in the exploration of the pile structures indicate that they were used as the ordinary home of the people, and not merely as an occasional retreat for defensive purposes ; and we may conclude that they formed only a comparatively small proportion of the entire population. Whilst in this particular district the circumstances were especially favourable to the construction of this species of dwelling, the adjacent district was occupied by branches of the same people who erected a quite different kind of habitation. The country surrounding the low-lying lake-covered area of Holderness is constituted of rounded chalk hills intersected by deep river-less valleys. There is abundant evidence still existing on these hills that they were inhabited by a numerous and energetic people. Their summits are entrenched in every direction, culminating on Flamborough Head with the so-called Danes Dyke. These entrenchments were probably erected for purposes of defense, and as a last resort should they be driven from the Wold entrenchments, the inhabitants could retreat to the more strongly fortified area on Flamborough Head, difficult of access from the sea, and rendering a prolonged resistance on the land comparatively easy. Over the whole Wold district there are large numbers of mounds or tumuli which were erected as memorials of the dead, and the investigations of these has thrown much light on the habits and character of the people. The mounds are stated by Canon Greenwell (*British Barrows,* 1877) to contain the bodies of two distinct races of men; the older one characterized by a long head, much longer from back to front than broad; whilst more recent mounds contain bodies with round heads, in which the breadth equals or exceeds the length; with the latter implements of bronze, ornaments of bone and jet, and pottery of varied forms have been discovered, whilst in the earlier graves only implements of flint and stone have been found, together with pottery of a rude character, and quite distinct from that associated with the implements of bronze. Rounded stones for pounding grain are frequently found. The relationship between the long-headed, stone-using people and the broad-headed people, acquainted with the use of bronze, who lived on the Wolds, and the similar races who occupied the lake-dwellings is sufficiently remarkable, and indicates more than a probability that the race who built the entrenchments and erected mounds over their dead, occupied their strongholds at the same time that their neighbours, the lake-dwellers erected their island platforms. The implements found beneath the lower structure are similar to those got from diggings in the older tumuli, and there is simultaneous evidence of the introduction of bronze in the later pile-dwellings and the most recent of the mounds. Other examples of pile-dwellings have been recorded principally from the eastern counties, where in bygone centuries morasses and meres abounded. One at Barton Mere, near Bury St.

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* Exactly as the writer saw the tenant of a small plot of arable land operating a short time ago. The grassland had been dug with a spade and remained in hard clods ; to break up these the man had inserted a long stick in a solid piece of wood, pierced in a similar manner, and nearly the same size as the broken leg-bones of the ox, and with this was pounding away at the masses of dry earth ; a peculiar exemplification of an old-world custom revived by the force or necessity of circumstances.

Edmunds, was explored by the Rev. H. Jones in 1867; another at Wretham Mere, in Norfolk, by Sir Charles Bunbury in 1856; and Dr. Palmer has reported that in 1869 oaken piles and planks had been dug out of boggy ground on Cold Ash Common, Berkshire. In each instance piles were found driven into the ground, at Barton supported by large stones; associated with them were vast quantities of broken bones of animals used for food, and occasionally bronze spear-heads and other implements have been found. It is probable that these structures belonged to the bronze age, and the objects discovered in them point rather to the later than to the earlier part of it; to that portion which immediately precedes the historic period. Compared with the lake-dwellings of Holderness they would be coeval with the more recent structures in which the bronze implements are found. A single example of a Crannoge or pile-dwelling has been recorded as occurring in Llangorse Lake, near Brecon, in South Wales. It consists of an island of piles supported by stones; it is ninety yards in circumference, and situated in two or three feet of water a short distance from the northern shore of the lake. The piles are oak and show evidence of having been hewn with a metal adze. Outside the island are groups of piles of softer wood, and it is inferred that the island formed a central platform from the circumference of which the dwellings extended to the adjacent groups of piles. Large quantities of bones were found in the shallow water between the island and the margin of the lake. The bones were submitted to the late Professor Rolleston, who found them to be entirely those of the pig, sheep, cow, and horse; they were all representative of small animals. The horse was used as an article of food, its bones were of two kinds, one small, probably the progenitor of the Welsh pony, and the other of a larger breed. To the above list Professor Boyd Dawkins afterwards added the red deer and wild boar. Some fragments of pottery were found interspersed with the bones.

In Ireland and Scotland numerous Island Lake-dwellings or Crannoges have been discovered. A large number of the Irish ones were described by Sir W. R. Wilde in the proceedings of the Royal Irish Academy, dating from 1840. The Irish Crannoges have been inhabited from a period hidden in remote antiquity until comparatively recent times. In many instances they may have been deserted for long periods, and afterwards repaired and re-inhabited. The remains of implements of war; those used in agricultural pursuits and others for personal adornment, range through all the varieties of stone and flint, bone, bronze and iron, and consist of daggers, spears, knives and swords, shears, axes, querns, beads, pins, combs, brooches, chains, pots, &c. The amount of broken bones left by the occupiers is enormous, and instances are recorded where a hundred and fifty cart-loads had been removed and used as manure from a single plat-platform. The ordinary form of the Irish Crannoge is a circular or oblong structure forming an island, surrounded by one or more rows of piles, pointed and driven into the bed of the lake. Inside the circle of piles the space is filled with stones, branches of trees and peaty *débris*. On those artificially-built islands, wooden dwellings were erected. The latter consisted of a combination of piles and wicker-work with boarded floors. In districts where wood was scarce, they are sometimes built up entirely of stone. Generally the dwellings were erected in a circle round the outer extremity of the structure, similarly to that already spoken of in Wales; in other and rare instances the houses were built on wooden platforms supported by piles and brushwood, held in position by stones. They were erected without connection with the shore, communication being made by means of a canoe, hewn from the bole of a single tree: it is a common occurrence to find the canoe in immediate proximity to the pile structure buried in the peat or bog. Sir W. R. Wilde describing a Crannoge exposed at Lagore, County Meath, which was 173 feet in diameter, says—

"The circumference of the circle was formed by upright posts of black oak, measuring from six to eight feet in height; these were mortised into beams of a similar material, laid flat upon the marl and sand beneath the bog, and nearly sixteen feet below the present surface. The upright posts were held together by connecting cross-beams, and (?) fastened by large iron nails; parts of a second upper tier of posts were likewise found resting on the lower ones. The space thus enclosed was divided into separate compartments by septa or divisions that intersected each other in different directions; these also were formed of oaken beams in a good state of preservation, joined together with greater accuracy than the former, and in some cases having their sides grooved or rabbeted to admit large panels driven down between them. The interiors of the chambers so formed were filled with bones and black moory earth, and the heaps of bones was raised up in some places within a foot of the surface."

The animals whose remains were thus preserved were principally oxen, horses, asses, pigs, sheep, goats, deer, dogs and foxes. Some human bones were also found.

Nearly one hundred lake-dwellings have been discovered in Ireland, and about the same number is recorded as having received more or less attention in Scotland; of the latter fifty are entirely built of wood, and the remainder wood and stone combined or other materials. The Scotch Crannoges, in all essential particulars, are similar to those of Ireland, and were probably erected by the branch of the Celtic people who migrated northwards, whilst those of Ireland and Wales were the result of the influx of the Celtic element in its extension westwards. "The ordinary construction of the Crannoge proper" says Dr. Stuart "was by logs of wood in the bed of the lake, supporting a structure of earth and stones, or of a mixture of both, the mass being surrounded by piles of young oak trees in the bed of the lake, the inner row of which kept the island in shape, and the external rows acted as defences and breakwaters." Dr. Monro after prolonged investigation and experience was able to supplement the description given above as follows:—For defence and protection which I presume no one will doubt, were the primary objects of these islands, a small mossy lake, with its margin overgrown with reeds and grasses, and situated in a secluded locality amidst the thick meshes of the primeval forest of those days. would present the most desirable topographical conditions. Having fixed on such a locality the next consideration would be the selection of materials for building the island. In a lake containing the soft and yielding sediment due to decomposed vegetable matter, it is manifest that any heavy substance, as stones and earth, would be totally inadmissible owing to their weight, so that solid logs of wood, provided there was an abundant supply at hand, would be the best and cheapest material that could be used. To construct in ten or twelve feet of water, floating over a quagmire, a solid compact island, with a circular area of 100 feet or more, and capable of enduring for centuries as a retreat for men and animals, was a work requiring no small amount of engineering and mechanical skill on the part of these early Crannoge builders. The method of procedure suggested by Dr. Monro is that immediately over the chosen site a circular raft of trunks of trees, laid above branches and brushwood was formed, and above it additional layers of logs, together with stones, gravel, etc., were heaped up till the whole mass grounded. As this process went on upright piles, made of oak and of the required length, were inserted into prepared holes in the structure, and probably also a few were inserted into the bed of the lake. When a sufficient height above the water line was attained a prepared pavement of oak beams was constructed, and mortised beams were laid over the tops of the encircling piles, which bound them firmly together. When the skeleton of the island was thus finished a superficial barrier of hurdles, or some such fence, was erected close to the water. Frequently a wooden gangway, probably submerged, stretched to the shore, by means of which secret access to the Crannoge could be obtained without the use of a canoe.

The remains of pile structures were exposed near London Wall in 1866, when excavations were made for the foundation of a wool warehouse; associated with the piles there was a large number of various implements of a comparatively modern date, together with Roman coins which had been used by the inhabitants.

The lake-dwellings of Holderness bear the impress of greater age than any others in the British Islands, and they are of sufficiently characteristic structure to distinguish them from the island-like Crannoges of Ireland and Scotland. The ancient people who built them, having found a suitable situation, proceeded to cut down large trees by means of their rude flint axes; these, cleared of branches, were dragged to the lake side, and in five or six feet of water were laid horizontally along the bottom, and held there by stakes driven into the sandy or peaty shore. The level of the platform was raised by means of smaller trunks and branches to the level of the water, and an even surface obtained by twigs, gravel, and sand. On this there was probably erected a number of huts. As to the character of the huts there is no information. The several operations in connection with so large an undertaking, conducted by a people possessing no mechanical appliances and only the rudest tools, implies a large amount of intelligent co-operation, and consequently a comparatively advanced stage of civilization. The men appear for the most part to have been peaceable and industrious, dividing their time between the chase and the cultivation of the soil ; whilst the women attended to household duties, cooked the flesh of animals caught in the chase, or pounded the corn with rounded stones to make bread. Probably they spun the wool of sheep, as indicated by the presence of whorl stones, and made a coarse cloth. But the skin of the sheep with the wool attached was most likely to be the ordinary covering for the body. They appear to have had all the essential elements of happiness, and unfettered by the trammels of the intensely complicated civilization of their successors of subsequent centuries, to have pursued a tranquil and easy existence. This picture has its shadows, and no doubt occasional disagreements arose, and neighbouring tribes would quarrel and fight ; or perhaps combine against some more distant foe. After such engagements there is the probability that, like nearly all existing peoples in a similar stage of development from rudest barbarism, the captives were killed. The presence of the skull and bones of a human being amongst the *débris* found in the excavations of the lake-dwelling at Ulrome, as well as other evidences in the neighbouring Wolds, goes a long way to show that the people were cannibals.

Mention has been made of the principal lake-dwellings found in the British Islands ; it would be interesting, did space permit, to trace their relationship with others found on the Continent of Europe, and more especially with those, the remains of which exist, on the shores of the lakes of Switzerland, so admirably investigated and described by Dr. Ferdinand Keller, and which have afforded so good an opportunity for investigation during the past year by the low level of the waters of Lake Constance. The Swiss lake-dwellings are, with few exceptions, of an older type than those found in Great Britain, and extend throughout the stone age, the succeeding period characterized by the use of bronze, and to the earlier stages of iron. Dr. Keller considers that the Swiss lake-dwellers were a branch of the great Celtic family which occupied Central Europe prior to the incursions of the Romans, and it is also the opinion of Dr. Monro and others that all the pile dwellings in this country were erected by the Celts, or Brit-Welsh as they have been styled, who occupied the country in pre-historic times. If such be the fact, the relative age of the structures in Holderness as compared with those of Scotland and Ireland would be the natural result of the migration of that people westwards. Their first access to the country was gained on the east coast, and the pile-dwellings found in the eastern counties and in Yorkshire were probably the first erected. As the Celts were driven westward and northward by the incursions of succeeding nationalities they crossed over to Wales, Ireland, and Scotland, and erected pile-dwellings or Crannoges in those countries. It is probable that the Holderness dwellings were in a state of disuetude before the historic period ; they contain no traces of any objects of Roman or other civilized manufacture. On the other hand those of Ireland and Scotland are known to have been used as places of habitation and for defensible retreats, as recently as the sixteenth or seventeenth centuries. The pile-dwelling found near the old walls of London is also comparatively modern as compared with those of Holderness, and is replete with objects bearing the impress of the Roman occupation. It indicates a period when that part of the city was neither more or less than a great bog extending from the banks of the Thames.

It appears that the people in those old days adapted themselves to the circumstances of their environment very much as the savage nations of the present day do in New Guinea, in parts of Africa, and in other places. Where the country is full of lakes and of a wet and boggy character the inhabitants have found it necessary to provide a dwelling place raised above the water, and this has been done by driving piles into the soft ground and building on the top of them. At the same time their neighbours, of the same tribe, under more favourable circumstances, have erected their huts on the adjacent dry land.

THE FUTURE EXTENSION OF THE SOCIETY. BY THE MARQUIS OF RIPON, (PRESIDENT).

The President, in moving the adoption of the Annual Report, congratulated the Society upon its position. The Society continued to hold its own as regarded numbers, though he might remark that it was not in the nature of scientific societies of that description to increase their number of members to any large extent. Indeed, he did not know, from one point of view, whether they should very much desire any sudden increase in the number of members of a society of that description, because what they wished was the benefit of the Society, and it was certainly of some importance that the Society should be composed of men who were interested in the investigations and work of science. What they wished to see was a steady advance. There was one matter alluded to in the report which was of vital interest to the Society, and that was the assistance they received from their local secretaries. All of them who had been connected with the Society knew very well that Mr. Davis had done a good work, and that his services had been of the most valuable character. An allusion had also been made to the history of the last fifty years of the Society; we celebrated its jubilee last year. Looking back over the last fifty years, as they were called upon to do on that occasion, they felt that the work which had been done in the half century was not at all discreditable to the Society in whose interests they were now met, and it was very desirable that an adequate record should be kept of the proceedings during the period he had named. The aggregate of these investigations, when they were brought together, as they would be in the book or history referred to, would become of real value, real scientific value, and it would be recognized by scientific men when they were able to read the record of those labours. He was further led to refer to the investigations conducted by the Society with regard to the coal-fields of Yorkshire. Plans and maps had been prepared by members of the Society before the Geological Survey was entered upon, and from those facts it became evident the efforts of the Society had not only been in the interests of the geological investigations, but that the interests of commerce, the commercial interests of that great mining district, had been advanced; and the record could not fail to be interesting, not only to men of science, but also, he should imagine, to those who were engaged in the industry of coal-mining. His Lordship then alluded to that portion of the report having reference to the efforts which had been made with respect to pre-historic phenomena, and he said the labours in that direction not only marked the progress that had been made, but indicated the way in which further advances might be made. He mentioned the fact that men of high reputation in the scientific world had honoured the Society and acknowledged its utility. The report spoke of the investigations which had been made of the sea-beach at Bridlington. They made a grant of £10 for those investigations, and the British Association had made a further grant of £20. He thought that was a proof that the investigation was conducted in the right direction. He congratulated the Society upon the fact that the British Association, in appointing a committee to consider and report upon the Prehistoric Remains of the ancient inhabitants of Great Britain, chose among the number Mr. Davis, the secretary of their own Society. The report reminded him that their Society had lost the services of Professor Green, who had obtained and well deserved a promotion which carried his talents to the University of Oxford as their geological professor. They might well be gratified that one of their number had been thought fit and worthy to fill such an important office as that to which Professor Green had been called. There was a matter connected with the work of the future of that Society upon which he would like to say a few words. He could not help thinking that the future utility of the Society might be considerably enhanced. He believed it would be a very good thing if the Society could be brought into direct communication with more purely local Societies; it would require a certain amount of diplomacy on the part of those who undertook to carry it out. There were geological field clubs which existed in many other places, and if such could be affiliated to the county Society and worked to a certain extent in combination with it, then the advantages to both as the result of such a union would be great. It would be advantageous because such an arrangement would undoubtedly increase the interest in their work. If they had such an affiliation of bodies, large and small, in different parts of the county, the members of which were engaged in scientific investigation, they would be likely to take a deeper interest in their work than they do at present. Another advantage following such an arrangement would be gained by the general cause of science, for there would be a greater certainty of securing a full and adequate record of the scientific investigation going on and the facts brought to light by that research. It might be very difficult to estimate the real value of any scientific fact of which they acquired the knowledge. The fact which might at first seem of little value might bring out the true principle, and the result would be an advance of the cause of science in a way they had not been expecting. It was the duty of every student of science to record in his own note-book every scientific fact he could add to those previously known. He need not dwell upon the advantages to be gained by the combination and co-operation of the larger bodies with the smaller. Whether the movements were political, social, or scientific, they would all agree that combination and co-operation would tend to the furtherance of those objects. It was true with regard to scientific inquiries, as it was in any other work going on in the country, that if there could be a direct interchange, and communication, it worked to the advantage of all concerned. There were connected with those local bodies many members who were not sufficiently possessed of this world's goods to be able to pay the subscription demanded by their Society. They ought to offer such men every means of making themselves acquainted with the proceedings of their Society. He had been induced to make those remarks in the hope that practical steps would be taken with a view of making some arrangements by which the local bodies might be offered an affiliation upon the payment of a certain annual subscription on behalf of the Society. He was disposed to think that if an arrangement of that kind were effected, the members of the affiliated Societies might be permitted to attend the meetings of the Yorkshire Geological and Polytechnic Society. In conclusion, his Lordship said that both as regarded the balance-sheet and the general details of the report, the report was one with which they might well be satisfied.

SECRETARY'S REPORT.

The number of members remains the same this year as last. The Society has elected an additional eleven members during the year, and has lost three by death, one of whom, Mr. Thomas Lister, had been local secretary at Barnsley for many years ; his loss is felt very much ; eight members have retired.

Three meetings, including the present one, have been held during the year. The first was at Leeds on June 27th, at the Philosophical Hall, when Professor A. H. Green, F.R.S., occupied the chair, and papers were read by the Rev. E. Maule Cole, M.A., Messrs. C. E. De Rance, and Geo. W. Lamplugh. After the meeting the Society had the pleasure to entertain Professor Green at dinner at the Great Northern Hotel, on the occasion of his leaving the Yorkshire College to accept the Chair of Geology at Oxford University. The President of the Society, the Marquis of Ripon, occupied the chair. Amongst those present were Principal Bodington, Professors Miall, Smithells, Barr, Lupton, Messrs. De Rance, O. Nussey, C. E. Bousfield, and others, together with about fifty members of the Society. Apologies for unavoidable absence were received from Professors Greenwood, Williamson and Boyd Dawkins, who were detained by a college meeting at Owen's College, and from Professor T. McKenny Hughes, of Cambridge.

The second was a combined meeting and excursion, and took place on Wednesday, August 29th. The members met at Skipton, and were joined by the members of the Skipton Naturalists and Scientific Association. The party, about forty in number, proceeded in conveyances to Thorpe, and visited the Elbolton Cave. Considerable time was taken in its investigation, and a large number of bones of men and animals were obtained. The Rev. Mr. Jones, of Embsay, a member of the Skipton Society, read a paper on the Recent Discoveries in the Elbolton Cave, which will be found in the proceedings of the Society. The Mountain Limestone of the neighbourhood is rich in fossils ; many examples were collected. The conveyances bore the party thence to Burnsall in Wharfedale, where dinner was provided. A meeting was afterwards held at which papers were communicated by Mr. G. R. Vine on the Classification of the Palæozoic Polyzoa, and by Mr. W. J. E. Binnie on the Mesozoic Rocks of the N.E. coast of Ireland. After the meeting the drive was continued by Bardon Tower and Bolton Woods to Skipton. The excursion was much enjoyed.

The third meeting, which was the annual one, was held in the Lecture Theatre of the Philosophical Society, Halifax, on Tuesday, December 18th, at 3-0 p.m. The President, the Marquis of Ripon, occupied the chair. The usual business of the annual meeting was transacted, and papers read by Mr. J, Spencer, on Granite Boulders in Coal; Mr. J. W. Davis, on Lake Dwellings; and by Mr. G. R. Vine, Part I of a Monograph of Yorkshire Carboniferous and Permian Polyzoa. After the meeting the members dined together at the White Swan Hotel; the Marquis of Ripon presiding.

To the Honorary Local Secretaries the Society is greatly indebted; to their energetic action much of its success must be attributed. The following list specifies the localities and those in charge :—

Bradford	Thos. Tate, F.G.S., 5, Bagby Road, Leeds
Bridlington	G. W. Lamplugh, Bridlington Quay
Brighouse	Thomas Ormerod, Brighouse
Driffield	Rev. E. M. Cole, M.A., Wetwang
Halifax	Geo. Patchett, Junr., Halifax
Harrogate	R. Peach, Harrogate
Huddersfield	P. Sykes, 33, Estate Buildings
Leeds	S. A. Adamson, F.G.S., 52, Well Close Terrace
Leyburn and Wensleydale	W. Horne, Leyburn
Thirsk	W. Gregson, Baldersby, Thirsk
York	H. M. Platnauer, The Museum, York.

The proceedings and memoirs of the learned Societies, whose names are appended, are forwarded to this Society; in exchange, our proceedings are sent to them. The thanks of the Society are due and hereby tendered to those Societies for their respective contributions.

Essex Naturalists Field Club
Norwich Geological Society
Memorias de la Sociedad Cientifica "Antonio Alzate" Mexico
Yorkshire Archæological and Topographical Society
Warwickshire Natural History and Archæological Society
Royal Society of Tasmania, Van Dieman's Land
Royal Dublin Society

Royal Historical and Archæological Association of Ireland
Geologists' Association, London
Manchester Geological Society
Literary and Philosophical Society, Liverpool
Royal Institution of Cornwall
Royal Geological Society of Ireland
Midland Naturalist, Birmingham
Academy of Natural Sciences, Philadelphia, U.S.A.
Naturhistorischen Hofmuseum, Wien, Austria
Societie Imperiale des Naturalistes, Moscow
United States Geological Survey of the Territories, Washington
Boston Society of Natural History, U.S. America
Hull Literary and Philosophical Society
Connecticut Academy of Arts and Sciences
Academy of Science, St. Louis, U.S. America
Historical Society of Lancashire and Cheshire
Geological Society of London
Royal University of Norway, Christiana
Sociètè-Geologique du Nord, Lille
Royal Society of Edinburgh
Royal Geological Society of Cornwall
Royal Physical Society of Edinburgh
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club
Birmingham Natural History and Microscopical Society
Bristol Naturalists' Society
Leeds Geological Association
Patent Office Library, London
Powis Land Naturalists' Club, Aberystwith
American Philosophical Society, Philadelphia, U.S.A.
Comité Geologique de Russie, St. Petersberg
Elisha Mitchell Scientific Society, Chapel Hill, U.S. America

The history of the fifty years existence and work of the Society, with biographical notices of some of its prominent members who are deceased, is rapidly approaching completion, and will probably be placed in the hands of members during the early months of the year. It has assumed somewhat larger proportions than was anticipated, and in consequence of the expense incurred in its passage through the press your Council have decided to recommend that no photograph be issued with the proceedings of the current year.

An exploration of the ancient Sea Beach at Sewerby, near Bridlington, was commenced by this Society under the charge of Messrs. Lamplugh and Boynton, with a grant of £10 ; a report of their labours appeared in last year's proceedings. The investigation has been continued during the present year, the expenses being defrayed by a grant from the British Association. Important results have accrued, and a description of some of these will be found in Mr. G. W. Lamplugh's paper read at the Annual Meeting.

Your Honorary Secretary attended as a delegate representing this Society at the meeting of corresponding societies of the British Association at Bath. A further report of the pre-historic evidences of the existence of man in the British Islands was presented, consisting of a voluminous report from the Rev. J. M. Mello, M.A., relating to Derbyshire.

The Treasurer's financial statement is appended.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society, 1887-8.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
To Balance in Banker's hands, October 22nd, 1887	20	4	10	By Photographs, Plates and Engraving...	26	17	8
,, Subscriptions and the Corporation Dividend	70	0	1	,, Advertising and Printing	40	0	0
				,, Sundry small accounts	1	16	7
				,, Raygill Exploration	5	15	0
				,, Balance in hand	15	15	8
	£90	4	11		£90	4	11

CAPITAL ACCOUNT.

To Halifax Corporation Bond ... £350 0 0

W. CASH, Treasurer.

31st October, 1888.

MINUTES OF MEETINGS.

Meeting of the Council May 9th, 1888, at the Museum, Leeds.

Present—Mr. T. W. Embleton, in the chair; Messrs. Reynolds, Gray, Tate, and Davis.

The minutes were read and confirmed.

Mr. Reynolds reported that he had made enquiries respecting the early Minute Books of the Society, but without success. A list of members in 1871 was obtained from Prof. Miall, together with some copies of the Rules, printed in 1840.

Mr. Gray proposed and Mr. Reynolds seconded that the following accounts be paid:—

	£	s.	d.
Meissenbach & Co.	7	12	0
Autotype Co.	10	10	0
Mintern Bros.	8	15	0
J. W. Shores	1	6	8
Wormald Bros.	0	2	9
W. Townend	1	6	0
J. Potterton (reporter)	3	10	0

A letter having been read from Mr. Husband, the Secretary of the Yorkshire College, stating that this Society has been placed on the list entitled to appoint a Governor on the Board of Governors at the Yorkshire College, and requesting that one be appointed, it was resolved on the motion of Mr. Tate, seconded by Mr. Gray,

That Richard Carter, Esq., C.E., be appointed.

It was resolved that the next meeting be held at Leeds in June, and that after the meeting Professor A. H. Green be entertained at dinner by the Society. That the dinner be at the Great Northern Hotel, and that members be allowed to invite or take tickets for friends.

That the following gentlemen be invited by the Society, viz.:—Principal Bodington, Professors Miall, Barr, Lupton, and Smithells, of the Yorkshire College; Principal Greenwood, Professors Williamson and Boyd Dawkins, of Owen's College, and Professor Hughes, of Cambridge; and that the President, the Marquis of Ripon, be requested to preside, and that the Hon. Sec. make such preliminary arrangements as may be necessary, and afterwards call together the Council again.

Meeting of the Council at the Museum, Leeds, June 6th, 1888.

Present : W. Cheetham, Esq., in the chair ; Messrs. Peach, Platnauer, Adamson, Bedford, Tate, Parke, Rowley, Reynolds, and Davis. Apologies were read from Mr. Eddy and Mr. Carter.

The minutes of the last meeting were read and confirmed.

The Hon. Secretary reported that the President, the Marquis of Ripon, could not preside at the meeting to be held in June, and further that Lord Houghton had been communicated with and that he also was prevented from presiding by engagements already made.

On the motion of Mr. Parke, seconded by Mr. Peach, it was resolved that R. Carter, Esq., C.E., J.P., be requested to preside.

Mr. Platnauer proposed and Mr. Adamson seconded that the date for the next meeting be June 27th, at 3-0 p.m.

Resolved that Messrs. De Rance, Lamplugh, and the Rev. E. Maule Cole read papers at that meeting.

Mr. Parke proposed and Mr. Rowley seconded that Mr. J. T. Atkinson, F.G.S., of Selby, be elected a member of the Council in the place of Dr. Wm. Alexander, deceased.

The Hon. Secretary reported that the Council of the Leeds Philosophical and Literary Society had intimated their intention to charge 7s. 6d. for the use of the room at each Committee Meeting. The Hon. Secretary was requested to communicate with the Leeds Philosophical and Literary Society thereon ; to explain the relative position of the two societies existing hitherto ; and to request that the following arrangement be renewed and maintained, viz..:—That in consideration of the collection of fossils, &c., which were deposited in the museum by this Society still remaining there, the Yorkshire Geological and Polytechic Society may hold meetings of its members or council in the rooms free of charge.

General Meeting, Philosophical Hall, Leeds, June 27th, 1888.

Prof. A. H. Green took the chair, on the motion of Mr. Cheetham, seconded by Mr. Embleton. An apology was read from Mr. Carter, who was too unwell to be present. The minutes of the last meeting were read and confirmed.

The following gentlemen were proposed members of the Society and duly elected :—

J. D. Taylor, Esq., Halifax.
Rev. J. Critchison, Elland.
Sir Tatton Sykes, Sledmere, York.
Riley Briggs, Esq., Osgoodby Hall, Selby.
Oswald Dawson, Esq., Leeds.
Henry Seal, Esq., Vale Head, Knottingley.

The following papers were read :—

C. E. De Rance, A.I.C.E., F.G.S., of H.M. Geol. Survey, "Notes on the age of the Cave deposits of the Vale of Clwyd."

Rev. E. Maule Cole, M.A., "Notes on the ancient entrenchments in the neighbourhood of Wetwang."

G. W. Lamplugh, Esq., "On the larger boulders of Flambro' Head." Part II.

Discussion followed on the papers, Messrs. Lamplugh, Tate, Green, Seal, Cole and De Rance taking part.

After the meeting the members and friends adjourned to the Great Northern Hotel, where the Society entertained Professor A. H. Green, F.R.S., F.G S., at dinner, before he left Leeds and the Yorkshire College to commence duty at Oxford. The President, the Marquis of Ripon presided, and was supported by Principal Bodington, Professors Miall, Lupton, Smithells, Barr, and others from the Yorkshire College, and a large company. Letters of apology were read from Principal Greenwood, Professors Williamson and Boyd Dawkins, of Owen's College; from Professor Hughes, of Cambridge; and others. The health of Professor Green was proposed by the president, and heartily responded to; other toasts also followed.

Meeting of the Council, August 22nd, 1888, Philosophical Hall, Leeds.

Present, Professor A. H. Green in the chair; Messrs. Bedford, Parke, Cash, Eddy, Atkinson, Adamson and Davis.

The minutes were read and confirmed.

The Honorary Secretary read a letter from the Secretary of the Philosophical and Literary Society of Leeds, in answer to that of the Honorary Secretary of June 8th, having reference to the charge for use of rooms at the Hall, stating that the council of the Leeds Society rescinded the resolution to charge 7s. 6d. for each meeting, and continued the arrangement hitherto subsisting with the members of the Yorkshire Geological and Polytechnic Society to make use of their rooms free of charge.

The following accounts were ordered to be paid :—

	s.	d.	
Yorkshire Post	8	3	
Leeds Mercury	7	6	
E. Cassino	8	7	(2·07 dols.)

Mr. J. T. Atkinson proposed, Mr. G. H. Parke seconded, and it was carried, that the arrangements made for an Excursion to Elbolton Cave, Burnsall, and Thorpe Fells be confirmed.

Proposed by Mr. Parke, seconded by Mr. Eddy, and carried, that the tender submitted by Messrs. Whitley & Booth, for printing 400 copies of the Historical Sketch of the Society, uniform with its Proceedings be accepted.

Proposed by Mr. Cash, seconded by Mr. Atkinson, and carried, that no photograph be issued with the current year's Proceedings.

General Meeting and Excursion to Elbolton Cave, Thorpe, Burnsall and Barden, August 29th, 1888. Thirty members and friends were met at the Skipton Station by the members of the Craven Naturalists' Society with conveyances. At Skipton the party inspected the collection of bones from Elbolton Cave, and a number of Mountain Limestone Fossils exhibited by Rev. Ed. Jones and the Craven Naturalists' Society at the Town Hall. The party drove to Thorpe Fells, and visited the cave in Elbolton Hill, and thence to Burnsall. Dined at the Red Lion Inn.

A meeting was held on the Bridge at Burnsall. Mr. T. W. Embleton was voted to preside.

On the proposition of the Hon. Secretary, seconded by Mr. W. Rowley, Messrs R. Moffatt Kerr, Solicitor, Halifax, and Brook Rowley, Weymouth Street, Halifax, were elected members of the Society.

The following papers were read :—

Rev. Ed. Jones, "On the Recent Discoveries at Elbolton Cave in Thorpe Fells."

G. R. Vine, Esq., "On the Classification of the Palæozoic Polyzoa."

W. J. E. Binnie, Esq., "On the Mesozoic Rocks on the N.E. Coast of Ireland."

A vote of thanks was proposed to the Skipton Naturalists' Society and to the Rev. Ed. Jones for their kind assistance in arranging the visit to the cave, and the paper thereon, by Mr. Cheetham, seconded by Mr. J. E. Bedford, and carried with acclamation.

A vote of thanks to the chairman concluded the proceedings.

The party drove by way of Barden Tower and Bolton Abbey, one section returning by the Ilkley route, and the remainder continuing to Skipton.

Meeting of the Council Philosophical Hall, Leeds, Oct. 24th, 1888.

Present: R. Carter, Esq., J.P., in the chair ; Messrs. Adamson, Eddy, Cheetham, and Davis.

Proposed by Mr. Eddy, seconded by Mr. Cheetham, that the Marquis of Ripon (president) having expressed his willingness to preside at the annual meeting, if it can be held at Halifax, on the 18th December,

Resolved that his Lordship's suggestion be accepted.

Proposed by Mr. Adamson, seconded by Mr. Cheetham, that papers be accepted from Messrs. Lamplugh, Vine, Tate, and Davis, to be read at the annual meeting.

Annual Meeting at the Museum of the Philosophical Society, Halifax, December 18th, 1888, at 3-0 p.m.

The President, the Marquis of Ripon K.G., presided.

The minutes of last general meeting were read and confirmed. Apologies were read from Messrs. Eddy, Skipton ; Atkinson, Selby ; Lamplugh, Bridlington ; Carter, Harrogate ; and others. The Hon. Secretary read the Annual Report and Balance Sheet. The noble Chairman gave an address, and proposed the adoption of the report.

The Rt. Hon. James Stansfeld, M.P., seconded the proposition, and it was adopted.

On the motion of Mr. J. W. Davis, seconded by Mr. W. Stott, the following gentlemen were elected members of the Society :—

Mr. H. J. Morton, Scarborough.
Mr. Samuel Utley, Halifax.
Mr. William Utley, Halifax.

Proposed by Mr. W. Cheetham, seconded by Mr. J. Davidson, and carried, that the Most Noble the Marquis of Ripon be re-elected President.

Proposed by Mr. W. Rowley, seconded by Mr. S. T. Rigge, and carried, that the Vice-Presidents be re-elected.

Proposed by Mr. J. H. Gray, seconded by Mr. J. E. Bedford, that Mr. J. W. Davis be re-elected Honorary Secretary, and that Mr. William Cash be re-elected Treasurer.

Proposed by Mr. O. Dawson, seconded by Mr. W. Cash, and carried, that the following gentlemen be the Council.

Atkinson, J. T.
Bedford, J. E.
Carter, R.
Cheetham, W.
Eddy, J. Ray
Embleton, T. W.
Gray, T. H.
Lupton, Prof. Arnold
Parke, G. H.
Reynolds, R.
Rowley, W.
Strangways, C. Fox.

Mr Cheetham proposed, and Mr. W. Stott seconded, that Messrs. Eddy, Rowley and Davis be requested to act as Delegates representing this Society on the general Local Committee to arrange for the meeting of the British Association at Leeds in 1890.

The following papers were presented or read :—

G. R. Vine, "A Monograph of Yorkshire Carboniferous and Permian Polyzoa."

Jas. W. Davis, "English Lake-Dwellings."

James Spencer, "On the Occurrence of Boulders of Granite in the Coal Measures near Halifax."

Mr. Davis proposed, and Mr. Cheetham seconded, that the Society tenders to the Council of the Halifax Literary & Philosophical Society its thanks for the use of the Lecture Theatre in which to hold this meeting.

Mr. Gray proposed, and Mr. Davidson seconded, that the thanks of the meeting be accorded to the Marquis of Ripon for presiding.

After the conclusion of the meeting the members adjourned to the White Swan Hotel, where they dined, the President in the chair.

SUMMARY OF GEOLOGICAL LITERATURE RELATING TO YORKSHIRE, PUBLISHED DURING 1888.

Compiled by JAMES W. DAVIS.

ADAMSON, S. A. Notes on a recent discovery of Stigmaria ficoides at Clayton, Yorkshire. *Quart. Journ. Geol. Soc.*, vol. xliv., p. 375.

——— On some sections exposed in making the Skipton and Ilkley Railway. *Proc. Yorksh. Geol. and Polyt. Soc.*, N.S., vol. ix., p. 363.

BARROW, GEORGE. The Geology of North Cleveland. *Geol. Survey Memoir*, London, 1888.

BEDFORD, J. E. Notes on flint-flake implements found in the Isle of Man. *Proc. Yorksh. Geol. and Polyt. Soc.*, N.S., vol. ix., p. 369.

BLAKE, J. F. On a Starfish from the Yorkshire Lias. *Rep. Brit. Assoc.*, Manchester, 1887, p. 716.

BOYNTON, THOMAS. On the bronze implements found in the East Riding of Yorkshire. *Proc. Yorksh. Geol. and Polyt. Soc.*, N.S., vol. ix., p. 426.

BROWNRIDGE, CHARLES. On the occurrence of Quartzite and other Boulders in the Lower Coal Measures at Wortley, near Leeds. *Ibid*, p. 405.

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Life members who have compounded for their annual subscriptions are indicated by an asterisk (*).

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⁂ It is requested that Members changing their residence will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1888.

SHEET 1.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, F.R.A.S., F.R.Met Soc., F.G.S., and Alfred Eley Preston, Assoc M. Inst. C.E., F.R.Met.Soc., F.G.S.
Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

MONTHS.	PRESSURE OF ATMOSPHERE IN MONTH. Highest Reading of Barometer.	Date	Mean of Highest of 20 Years.	Lowest Reading of Barometer.	Date	Mean of Lowest of 20 Years.	Range	Corrected for Capillarity and Temperature: Mean.	Mean of 20 Years
	Ins	On	Ins	Ins	On	Ins	Ins	Ins	Ins
January	30.333	10th	30.174	28.816	31st	28.686	1.517	29.767	29.516
February	30.141	28th	30.081	29.089	12th	28.782	1.052	29.632	29.504
March	30.044	1st	30.152	28.410	28th	28.787	1.634	29.194	29.497
April	29.937	6th	30.077	29.152	18th	28.830	0.785	29.474	29.479
May	30.148	23rd	30.066	28.842	1st	29.021	1.306	29.585	29.555
June	29.976	23rd	30.005	29.185	29th	29.166	0.791	29.537	29.556
July	29.762	13th	29.965	29.010	3rd	29. 52	0.752	29.320	29.511
August	29.964	18th	29.985	29.246	24th	29.077	0.718	29.562	29.513
September	30.199	13th	30.083	29.404	29th	28.965	0.795	29.771	29.508
October	30.159	21st	30.126	28.896	2nd	28.741	1.263	29.579	29.460
November	29.764	6th	30.028	28.678	27th	28.665	1.086	29.320	29.43
December	30.102	16th	30.101	28.689	22nd	28.657	1.413	29.501	29.458
Means, or totals	30.043		30.069	28.946		28.877	1.097	29.520	29.499

MONTHS.	TEMPERATURE OF AIR IN SHADE DURING MONTH. In Each Month. Highest	Date.	Mean of Highest of 20 Years.	Lowest.	Date	Mean of Lowest of 20 Years.	Range
	Deg	On	Deg.	Deg	On	Deg	Deg
January	55.2	11th	52.9	26.1	20th	23.6	29.1
February	49.8	7th	53.5	19.2	14th	26.4	30.6
March	54.2	10th	56.8	26.6	2nd	25.9	27.6
April	60.2	15th	64.4	30.4	8th	31.2	29.8
May	76.6	20th	70.0	37.0	9th	34.7	39.6
June	80.4	27th	77.4	40.0	5th	41.6	40.4
July	70.2	20th	80.1	42.0	11th	46.4	28.2
August	75.7	10th	78.6	44.0	1st	45.4	31.7
September	66.6	3rd	70.4	41.0	30th	39.9	25.6
October	64.0	28th	63.5	29.1	2nd	32.5	34.9
November	58.4	17th	56.4	34.9	28th	26.7	23.5
December	57.8	[illegible]	53.0	26.2	14th	23.4	31.6
Means, or totals	64.1		64.8	33.0		33.3	31.1

MONTHS.	Daily Mean. In Each Month: Of all Highest	Mean of 20 Years	Of all Lowest	Mean of 20 Years	Range: Mean	Mean of 20 Years	Of Dry Bulb: Mean	Mean of 20 Years
	Deg	Deg	Deg	Deg	Deg	Deg.	Deg	Deg
January	43.5	42.9	35.5	34.3	8.0	8.6	39.3	39.1
February	39.8	44.3	32.7	35.4	7.1	8.9	35.7	39.8
March	41.5	46.4	33.0	35.3	8.5	11.1	36.9	40.4
April	47.9	52.8	38.3	39.5	9.6	13.2	42.4	44.8
May	59.5	58.2	44.4	43.6	15.1	14.6	50.4	49.3
June	61.7	65.0	48.5	50.0	13.2	15.1	53.3	55.7
July	61.3	68.6	51.1	53.9	10.2	14.6	55.2	60.9
August	63.0	67.3	51.7	53.1	11.3	14.2	56.4	58.9
September	59.8	61.9	49.1	49.4	10.7	12.4	53.8	54.4
October	52.4	53.8	41.6	43.2	10.8	10.6	47.1	48.2
November	49.3	47.2	39.9	38.2	9.4	9.0	44.8	[illegible]
December	46.6	42.8	37.5	34.3	9.0	8.4	42.4	39.2
Means, or totals	52.2	54.2	42.0	42.5	10.2	11.7	46.5	47.7

MONTHS.	Adopted Mean Temperature. Of Air: Mean	Mean of 20 Years	Of Evaporation: Mean	Mean of 20 Years	Dew Point: Mean	Mean of 20 Years
	Deg	Deg	Deg	Deg	Deg	Deg
January	39.3	38.7	37.5	37.0	36.2	34.7
February	35.7	39.6	34.0	37.9	31.4	35.6
March	36.5	40.0	34.4	37.7	31.3	34.8
April	42.0	44.8	38.8	41.4	34.9	37.5
May	50.3	49.2	45.3	44.9	40.1	40.8
June	53.3	56.6	50.0	51.1	46.7	46.7
July	54.7	60.0	51.4	54.4	48.2	50.2
August	56.0	58.7	52.2	54.0	48.6	50.2
September	53.6	54.6	50.4	51.2	47.4	47.9
October	46.6	47.8	44.0	45.5	41.0	42.6
November	44.5	42.4	42.5	40.2	40.2	37.3
December	42.2	38.8	40.0	36.8	37.2	34.3
Means, or totals	46.2	47.5	43.4	44.4	40.2	41.0

MONTHS.	VAPOUR. Elastic Force: Mean	Mean of 20 Years	In a Cubic Foot of Air: Mean	Mean of 20 Years	Short of Saturation	Mean of 20 Years	Mean Weight of a Cubic Foot of Air.	Mean of 20 Years
	Ins	Ins	Grs	Grs	Grs	Grs	Grs	Grs
January	.206	.203	2.4	2.4	0.5	0.4	553	519
February	.178	.210	2.0	2.4	0.4	0.4	554	548
March	.177	.203	2.0	2.4	0.5	0.5	546	547
April	.204	.228	2.4	2.6	0.7	0.8	544	541
May	.248	.256	2.8	2.9	1.3	1.1	537	537
June	.318	.320	3.6	3.6	1.0	1.4	533	531
July	.337	.365	3.8	4.1	1.0	1.7	527	526
August	.345	.364	3.9	4.1	1.1	1.5	530	527
September	.326	.335	3.7	3.8	0.9	1.0	537	541
October	.259	.275	3.0	3.1	0.7	0.6	541	543
November	.249	.224	2.9	2.6	0.5	0.5	539	543
December	.223	.200	2.6	2.3	0.5	0.5	546	518
Means, or totals	.256	.265	2.9	3.0	0.8	[illegible]	540	539

MONTHS.	Degree of Humidity. (Complete Saturation = 100.) Highest	Date	Mean of Highest of 20 Years	Lowest	Date	Mean of Lowest of 20 Years	Mean	Mean of 20 Years
	0–100	On	0–100	0–100	On	0–100	0–100	0–100
January	97	11th	97	61	20th	67	86	86
February	96	25th	97	[illegible]	24th	67	84	88
March	99	15th	96	57	21st	67	82	83
April	92	21st	94	64	10th	53	77	77
May	92	3rd	[illegible]	41	23rd	44	68	73
June	96	6th	93	49	[illegible]	48	78	72
July	97	16th	91	43	27th	49	78	70
August	93	11th	92	52	31st	51	76	74
September	95	24th	96	66	[illegible]	66	79	79
October	99	18th	[illegible]	58	23rd	62	82	83
November	98	27th	96	[illegible]	[illegible]	63	85	83
December	98	27th	97	60	20th	66	84	84
Means, or totals	96		95	54		67	80	79

MONTHS	BRIGHT SUNSHINE. Greatest Daily Duration	Date	Total of Month.	Per cent. of Possible Duration.	TEMPERATURE OF AIR IN SUN'S RAYS. Highest.	Date	Mean of Highest of 20 Years	Mean	Mean of 20 Years.
	hr min	On	hr min		Deg	On	Deg	Deg	Deg
January	4 20	29th	14 50	6	62.2	27th	60.7	55.9	48.5
February	6 5	11th	49 55	18	71.8	10th	72.1	57.8	53.4
March	7 0	6th	69 40	19	72.8	22nd	83.0	61.7	62.0
April	8 50	2nd	76 35	18	84.0	15th	96.1	67.9	72.8
May	13 40	24th	162 5	33	100.0	[illegible]	104.1	83.2	81.0
June	13 30	24th	123 0	24	105.0	26th	110.6	86.7	87.7
July	10 20	20th	66 30	17	102.0	20th	113.1	82.6	91.7
August	9 0	15th	100 25	22	96.0	9th	109.8	81.6	89.1
September	8 5	7th	90 0	24	110.0	15th	99.8	89.0	80.9
October	8 30	7th	72 55	22	96.6	8th	86.7	81.3	67.7
November	6 30	1st	22 15	9	87.6	1st	72.2	70.4	56.2
December	4 50	10th	16 10	7	71.7	7th	68.4	62.8	47.8
Means, or totals	8 23		864 20	20	88.4		88.9	73.4	69.9

MONTHS	WIND. Direction: Relative Proportion of at 9 a.m. N.	NE.	E.	SE.	S.	SW.	W.	NW.
	No	No	No	No	No	No	No	No
January	4	2	2	5	3	3	5	7
February	4	11	2	0	0	1	3	8
March	3	8	2	5	0	3	5	5
April	6	6	0	3	1	4	6	4
May	4	3	2	3	6	3	7	3
June	5	4	5	7	2	0	5	2
July	3	10	1	5	1	4	6	1
August	4	4	3	2	3	4	10	1
September	4	5	3	6	1	3	6	4
October	7	1	0	3	2	6	10	2
November	0	2	8	5	2	6	7	0
December	7	1	0	2	9	4	2	6
Means, or totals	61	57	28	46	30	41	71	43

MONTHS	Velocity. At 9 a.m.: Mean	Highest.	Date	During 24 hours: Mean	Highest.	Date	Total Registered in Month.
	Miles p'r hr	Miles p'r hr	On	Miles per d	Miles per d	On	Miles
January	6.0	12.0	7th	150	357	26th	4636
February	7.5	17.4	5th	189	258	20th	5488
March	9.2	18.4	9th	177	316	9th	5501
April	8.5	15.0	30th	167	265	24th	4997
May	8.6	26.0	3rd	173	376	3rd	5348
June	7.0	12.2	12th	159	246	1st	4764
July	6.5	17.3	3rd	136	242	3rd	4221
August	6.4	12.6	13th	125	238	14th	3881
September	5.7	11.0	6th	125	[illegible]	7th	3741
October	6.5	17.4	[illegible]	148	330	28th	4588
November	11.0	26.7	24th	262	430	25th	7853
December	6.8	14.2	3rd	146	353	4th	4517
Means, or totals	7.4	16.7		163	312		59535

MONTHS	Pressure. Mean of all Daily Highest.	Mean of all Daily Highst. of 5 Years.	Highest.	Direction.	Date.	Mean of Highest of Month of 5 Years.
	lb per sq ft	lb per sq ft	lb per sq ft		On	lb per sq ft
January	1.76	3.31	11.00	W	26th	13.05
February	1.73	2.88	4.75	W	6th	10.15
March	1.79	2.27	6.75	W	8th	10.95
April	1.92	2.61	4.50	W	14th	9.65
May	2.70	2.66	13.00	W S W	4th	9.75
June	1.67	1.77	11.50	W	1st	8.05
July	1.79	1.76	7.50	W	4th	6.30
August	1.40	1.70	4.75	W	14th	7.05
September	0.96	2.10	5.50	S W	7th	7.05
October	1.32	2.57	5.50	S W	29th	9.75
November	4.60	2.70	12.00	W S W	[illegible]	11.12
December	1.35	3.16	6.25	S S W	4th	12.50
Means, or totals	1.92	2.46	7.75			9.56

MONTHS	Mean Amount of Cloud	RAIN. Number of Days it fell.	Amount Collected.	Greatest Daily Fall.	Date	Mean of 14 Years.	Mean of Seven Years' gauge with [illegible] ft. above surface of ground	Mean of [illegible] Yrs. gauge with [illegible] at T'n Hall and Mid Ry. Station on surface of ground	Gr'ter fall on surface at Town Hall & Mid Stn. than at 65½ft. above surface at Exch: Depth in Inches	Percentage of fall at Exch'ge
	0–10	No.	Ins	Ins	On	Ins	Ins	Ins	Ins	Per cent
January	8.6	13	0.79	0.19	26th	2.18	2.209	2.474	0.205	11.2
February	8.2	15	1.00	0.32	20th	[illegible]	2.609	2.972	0.363	11.4
March	7.5	20	3.35	0.55	12th	2.24	2.776	3.260	0.484	11.7
April	8.0	17	2.40	0.58	21st	2.10	2.516	2.835	0.313	11.2
May	6.3	8	0.79	0.33	30th	1.74	2.163	2.277	0.174	10.8
June	7.7	13	2.52	0.82	16th	[illegible]	2.837	3.611	0.174	10.6
July	7.4	19	4.12	0.94	3rd	[illegible]	3.161	3.641	0.240	10.7
August	7.2	19	1.82	0.86	29th	[illegible]	[illegible]	3.892	0.238	10.7
September	7.2	10	0.42	0.10	[illegible]	2.60	[illegible]	[illegible]	[illegible]	11.2
October	7.8	8	0.69	0.25	2nd	3.52	3.640	4.612	0.372	11.0
November	8.5	26	6.35	1.05	3rd	[illegible]	3.421	[illegible]	0.457	11.2
December	8.6	14	1.40	0.18	28th	[illegible]	3.181	4.170	0.489	11.1
Means, or totals	7.8	182	25.65	0.56		30.60	35.741	39.601	3.860	11.08

METEOROLOGY OF BRADFORD FOR 1888.

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, BRIGHT SUNSHINE, WIND PRESSURE, AND RAINFALL.

Year.	PRESSURE.				TEMPERATURE.								HUMIDITY. (Complete Saturation = 100.)				BRIGHT SUNSHINE.				WIND PRESSURE.		RAIN.							
	Highest		Lowest.		In Shade Highest		In Shade Lowest.		Last and First Frost of Seasons		In Sun's Rays Highest		Highest		Lowest										Gr'tr fall on srfce. at Tn H'll & Md Stn than at 65 ft ab've surf at Exc				Snow Last and First Snow of Seasons	
	Reading of Barom during Year	Date	Reading of Barom during Year	Date	R'ding of Maximum Thermom during Yr	Date.	R'ding of Minimum Thermom during Yr	Date	Date of Last Frost.	Date of First Frost.	Reading of Solar Thermom. during Yr.	Date	Degree of Humidity during Yr	Date	Degree of Humidity during Yr	Date.	Greatest Daily Duration	Date	Total of Year	Per cent of Possible Duration	Highest	Date	Total for Year	Mean Y'rly Rainfall at Town Hall and Mid Ry Stn on surface of g'nd	Depth in Inches.	Percentage of fall at Exch'ge	Greatest Daily Fall during Yr.	Date	Date of Last Snow.	Date of First Snow
	Ins		Ins		Deg		Deg				Deg		0 – 100		0 – 100		hr min		hr min		lb per sq ft		Ins	Ins	Ins	Per cent	Ins			
1869	30·290	Dec 6	28·500	Feb 1	85·2	Aug. 30	19·8	Dec 28	Mar 27	Oct 20	127·7	Aug 30	99	Feb 8	42	Sep 24													April 3	Oct 19
1870	**30·284**	**Jan. 19**	**28·308**	**Jan. 8**	**85·0**	**July 25**	**16·6**	**Dec. 23**	**Mar. 30**	**Nov. 9**	**127·5**	**July 25**	**98**	**Jan. 28**	**40**	**July 14**	......	......	......	......	......	......	**24·120**	......	......	......	**0·820**	**June 18**	**Mar. 24**	**Nov. 15**
1871	30·152	Mar 28	28·308	Jan 16	84·0	Aug 12	6·7	Jan 1	April 11	Nov 13	128·7	July 17	98	July 7	43	Nov 2							21·640				0·956	June 16	Mar 15	Nov 16
1872	30·156	April 6	28·070	Jan 24	86·4	July 23	24·8	Mar 27	Mar 27	Nov 19	124·8	Aug 19	100	Mar 22	45	Sep 23							42·000				2·400	June 19	May 11	Nov 11
1873	30·336	Feb 18	28·022	Jan 20	88·8	July 23	19·2	Feb 24	Mar 14	Nov 5	124·5	July 23	100	Dec 11	41	Mar 26							21·440				1·200	Aug 4	April 26	Jan 3, '74
1874	**30·476**	**Mar. 6**	**28·276**	**Dec. 11**	**80·9**	**July 20**	**15·0**	**Dec. 31**	**Mar. 12**	**Nov. 11**	**125·8**	**July 20**	**100**	**Feb. 6**	**42**	**May 18**	......	......	......	......	......	......	**23·660**	......	......	......	**0·740**	**Dec. 7**	**May 9**	**Nov. 26**
1875	**30·305**	**July 7**	**28·484**	**Nov. 10**	**80·0**	**Aug. 17**	**13·0**	**Jan. 1**	**Mar. 22**	**Nov. 26**	**122·0**	**July 5**	**100**	**Jan. 23**	**43**	**July 6**	......	......	......	......	......	......	**30·280**	......	......	......	**1·700**	**Nov. 15**	**Mar. 12**	**Nov. 9**
1876	30·350	Jan 15	28·070	Dec 4	87·6	July 17	23·0	Jan 9	April 15	Nov 9	125·6	July 16	99	Oct 4	46	May 5							35·270	39·788	4·518	11·28	1·810	Oct 9	April 12	Nov 8
1877	30·358	Oct 6	28·300	Nov 29	80·0	June 19	20·0	Mar 1	May 4	Oct 18	116·4	June 19	100	Oct. 29	35	May 23							40·650	45·499	4·849	11·19	1·420	July 16	May 19	Oct 15
1878	30·320	Mar 16	28·630	April 1	89·6	July 19	13·9	Dec 26	April 6	Nov 9	118·2	July 22	99	Jan 13	53	Aug 9							35·434	39·010	3·576	11·01	1·290	Aug 14	April 1	Nov 8
1879	30·352	Dec 13	28·500	Feb 10	74·4	July 30	13·2	Dec 7	May 10	Nov 14	101·2	Aug 13	100	Oct 7	51	Dec 12							28·017	30·298	2·281	10·82	1·020	June 8	May 7	Nov 20
1880	30·332	Jan 7	28·154	Nov 16	81·3	Sep 5	20·8	Jan. 20	Feb 23	Oct 20	112·0	Aug 13	99	Dec 15	50	May 30							35·690	39·616	3·926	11·10	1·710	Oct 27	Mar 2	Oct 27
1881	30·362	May 10	28·250	Oct 14	83·3	July 6	12·0	Jan 26	April 21	Oct 17	116·5	June 1	98	Oct 14	38	May 31							35·434	39·892	4·458	11·26	1·435	Oct 13	April 20	Oct 29
1882	30·544	Jan 18	28·452	Mar 1	77·4	Aug 12	18·6	Dec 11	April 16	Nov. 12	108·0	Aug 9	99	Nov 5	36	May 18							31·683	43·103	3·420	10·86	1·603	Dec 6	Mar 21	Nov 19
1883	30·500	April 9	28·452	Sep 2	76·2	July 3	19·3	Mar 10	Mar 29	Nov 12	107·6	May 17	99	Dec 26	30	April 9							34·396				1·363	Sep 26	Mar 21	Nov 10
1884	30·354	Oct 5	28·376	Jan 27	84·4	Aug 12	26·5	Nov 30	April 24	Nov 24	107·8	Aug 9	98	Jan 23	30	May 22					24·00	Jan 24	27·657				1·170	Jan 23	Feb 28	Nov 23
1885	30·273	Mar 14	28·460	Jan 11	82·2	July 27	22·1	Dec 11	April 6	Nov 16	113·6	July 27	100	Jan 23	32	June 4					15·25	Dec 4	25·499				1·208	Sep 3	May 7	Dec 9
1886	30·355	Nov 24	27·452	Dec 8	79·5	July 3	17·4	Mar 7	April 30	Dec 2	106·8	July 5	99	Jan 12	32	May 4	11 45	July 6	851 48	19	16·00	Dec. 9	35·993				2·130	July 26	May 12	Nov 6
1887	30·412	Feb. 8	28·328	Nov 3	82·8	July 9	21·1	Jan 17	April 17	Oct 12	107·6	July 9	100	April 21	35	July 9	12 40	July 3	1120 58	25	15·00	Feb 4	18·866				0·810	Oct 9	May 21	Oct 14
1888	30·333	Jan 10	28·410	Mar 28	80·4	June 27	19·2	Feb 14	April 8	Oct 2	110·0	Sep 15	99	Mar 15	39	June 11	13 40	May 24	884 20	20	15·00	May 4	25·6[illegible]6				1·050	Nov 3	April 8	Oct 1
Means	30·341		28·297		82·5		18·1				116·7		99		40		12 42		952 22	21	17·05		30·697	39·603	3·860	11·08	1·361			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8.40 p.m. the mercury of the Exchange barometer had fallen to 27·466 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

The sunshine is recorded in hours and minutes by glass sphere on cards fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a.m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·86 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the nineteen years ending with 1888 is 30·597 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 33·987 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

1/1921/Collated O.K.

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Geological & Polytechnic Society.

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WITH TWELVE PLATES.

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1889.

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1889.

BIOGRAPHICAL NOTICES OF EMINENT YORKSHIRE GEOLOGISTS.

NO. IV. HUGH EDWIN STRICKLAND, F.R.S., ETC. BY JAMES W. DAVIS.

Hugh Edwin Strickland was the second son of Henry Eustasius Strickland, a younger son of the late Sir George Strickland, Bart., of Boynton, and Mary, the eldest daughter of Edmund Cartwright, D.D., F.R.S. He was born on the 2nd March, 1811, at Reighton, in the East Riding of Yorkshire, a small village situate between Bridlington and Scarborough, looking down upon the beautiful bay of Filey. His father occupied a farm of considerable extent in the vicinity. The locality was retired, and the bold features of the neighbouring cliffs of Speeton and Filey could not fail to impress the mind of even a child, and there can be little doubt that frequent rambles on this interesting coast, and the fossils which he would pick up from the Speeton cliffs or the chalk escarpment, formed a strong basis towards his subsequent inclination to the study of geology. Strickland was in the habit, even when a boy, of writing down his impressions in the form of a journal. In this diary he records that his earliest recollections commenced when he was staying at Hildenley, near Malton, with two of his father's sisters, whilst his father, mother, brother, and sister, were on a visit to the south. This was in the end of 1814. "I remember the party returning and taking me home to Reighton. I also remember my fourth birthday which came soon after. About this time my above-mentioned aunts, whose names were Julia and

Charlotte, left Hildenley and bought a house in Gloucestershire, near Tewkesbury, having about three hundred acres of good land belonging to it, whither they went and have lived there ever since."

In the Spring of 1820, when he was nine years old, a private tutor was engaged to instruct him at home, and from that period the beginning of his classical education may be dated. Although the regularity of the proposed plan of education was interrupted by accidental circumstances, it was still continued until the year 1827 at his father's house. He then became a pupil of Dr. Arnold, before his appointment as headmaster of the Rugby School. In February, 1822, he met with an accident arising from a boyish exertion of strength, which sprained his back, and rendered necessary his removal to London, where he was placed under the care of Dr. Harrison, an old friend of the family. For many months he was obliged to maintain a reclining position, and it was nearly twelve months before his health was completely restored. This long illness must have been irksome to a comparative child, but a taste for reading was formed and encouraged, and a bias was given which influenced the future inclinations of his mind. "It will be easy thus to perceive," his mother writes, "the causes that seemed to encourage so marked a bias as he had already shown in favour of the physical sciences. The country around our new residence at Henley, has a very different aspect in its beautiful woods and meadows from that of Flamborough and Filey, it abounds in subjects of interest sufficient to gratify the most determined naturalist, and it was no wonder that feeling himself restored to health and strength he should eagerly return to those pursuits with delight, increased from the variety and novelty of a fresh field of observation." An additional encouragement had also arisen in the assistance of his brother Algernon, who had now arrived at an age to bring to memory the happy companionship of his much-loved brother Henry, and collections were formed and plans of classification devised by these yet juvenile and simple naturalists. Whilst on a visit to Yorkshire to his uncle, Sir William Strickland, in the Spring of 1824, he took the opportunity of going to Reighton, where he seems to have experienced a disappointment often felt by those who anticipate peculiar pleasure on revisiting the scenes of early childhood. "Poor Reighton is altered much, and chiefly for worse; many things are fallen down and but few are built up. Speeton Beacon and the aged patriarch of Thorn Tree Flat still exist, though probably in a mutilated state. Horses and cattle run at liberty about the plantation behind the stables and the yard, which is overgrown with weeds. The plantation at the back of the kitchen garden has got up surprisingly. It was with difficulty I could force my way through the shrubs to the seat and table, both of which I found buried among the trees." The general tendency towards a cultivation of natural history and of a somewhat roving disposition are illustrated by the following passage from his diary:—"A taste for natural history which I had acquired and which still continued unabated, was increased by a trip which our party together with Lady Strickland, her son Arthur, and her daughter Emma, took to Little Hampton in Sussex, where we spent seven weeks very agreeably in collecting shells, etc. In July I went with my father to Apperley in Gloucestershire, where we stayed a fortnight with my aunts, and then returned home, when I resumed my studies along with my two brothers. At the end of this year I was informed that it was settled that I should go to Oxford in three or four years' time. This was a death-blow to all my hopes, as I had always entertained a dread of going to college as being an almost inevitable cause of my taking root in England; whereas I had always cherished a hope of being a sailor, or at least of engaging in some locomotive profession, which should oblige me to roam about and see the world, and this hope, though repeatedly smothered, had never till this final decision of my fate been totally extinguished, and much did I grieve to see my cousin and former playfellow, George Cartwright, enter the navy, nay, to see my own brother and of late my almost only companion, Algernon, destined for the same profession, while I am doomed to spend the rest of my days in the capacity or rather incapacity of an English country gentleman." This was written in 1826, when Strickland was about fifteen years of age. In the Autumn of the same year, he spent some weeks in Lincolnshire with his uncle and aunt, Mr. and Mrs. Penrose. The latter was the daughter of Edmund Cartwright, and was the authoress of the popular Histories of England, France, etc., under the *nom de plume* of Mrs. Markham. Whilst there he wrote to his mother:—"I have now accumulated sufficient news to fill a letter. Mrs. Markham is deeply involved in the affairs of France, which are to be cleared up and publicly declared in December. A rival work is advertised under the title of History of Spain, on the plan of Mrs. Markham's History of England. Several of the engravings from France have arrived. They are on wood, and are well executed. You ask me how I employ my time. I am usually employed in learning Greek, etc., which my uncle is so good as to hear me say after dinner. Then in the middle of the day I either go to Lincoln with my uncle and aunt, both or neither, or I take a walk somewhere to potter after fossils. In the evening we generally read aloud to my great aunt Frances some of the Waverley Novels, or I read Parkinson's 'Organic Remains' to myself." At this time, as throughout the whole period of his life, Strickland was very industrious, and no branch of natural history appears to have come amiss. He was an indefatigable collector, and whether the objects lived in the air, gambolled in the water, or were preserved fossilized in the rocks, all seem to have come naturally under his supervision. In his diary of the 27th January, 1827, he records that he "finished writing the list of British shells with their habitats, which I flatter myself is very complete, as it contains many new species with a vast number of habitats. This work has occupied me, with the exception of three months when I was in Lincolnshire, since last April, and has been almost entirely composed between the hours of six and nine in the morning." A few days later he despatched a letter to the *Mechanics*' Magazine, signed "Boreas," describing a plan he had invented for uniting a wind gauge to a weathercock, and exhibiting the results of both upon two dial plates. Other short articles followed, and in due course appeared in the journal. He collected and stuffed birds, and probably about this time the strong attachment exhibited in after years to ornithological pursuits was formed and fostered. The ordinary school-boy's studies, however, were not neglected, and the tuition of Mr. Arnold laid a solid basis of future knowledge. He thus describes the routine course whilst under the care of this gentleman:—"Mr. Arnold sits in his own room, and each of us in turn go in to say our lessons to him twice a day according to the above-mentioned precedence, so that when the last has been in the first time, it is time for the first to go in the second time. The first lecture, as it is called, consists on Monday, Tuesday, Wednesday, and Thursday of Herodotus, and the second on Livy. On Friday and Saturday there is only one lecture. On the former of those days I do Sophocles, and on the latter am examined in Hallam's 'Middle Ages.' We go up about seven a.m., dine at 5-30 p.m., tea at eight, go to bed (or supposed to do) at ten p.m. We have, moreover, three themes a week, which are shown up on Saturday, and twice a week go in with Greek Testament between dinner and tea."

This year his father removed from Henley to Cracombe. The house was large, and as Strickland observes there was plenty of room for all their devices. During the boyhood of Strickland his secluded living and the character of his pursuits and tastes rendered him of a more or less retiring disposition, and he had an inclination to avoid the company of boys of similar age to himself and to feel more at home with people of more advanced years.

In February, 1829, he became a student at Oriel College, Oxford. The usual college amusements did not take much of his time, but he took great interest in the Museum then newly arranged by Mr. Duncan, and attended the geological lectures of Dr. Buckland, which he considered were so rational and interesting and agreed so well with all the notions he had before formed on the subject that he was quite delighted with them, while he considered it worth one's while if it were merely for the sake of examining his immense collection of organic remains. As usual, he kept a notebook on the Professor's lectures. In November Strickland passed his first examination, and thus reports his opinion of the proceedings:—"About half-past twelve yesterday I went into the schools. I was the first called up and was examined about twenty minutes. I was not nearly so frightened as I expected to be, and was quite surprised at myself, as I expected I should not be able to answer a word, instead of which I found myself very much at my ease. I was then set to do various translations, which occupied about two hours and-a-half, when the examiner said that all I had done was very satisfactory, and I was at liberty to go. After all, this same "Little-go" is a great farce, only few like to consider it so until they have passed it.

His vacation he passed with his father in Paris, and at the usual time resumed his studies at Oxford. He attended Dr. Kidd's anatomical lectures, and in the Autumn of 1831 retired to read with a tutor. He went to the Isle of Wight, and the sections of the rocks at St. Helen's, White Cliff Bay, and Alum Bay, immediately attracted his attention, and occupied a considerable portion of his time. He, however, did not neglect his studies, and in May passed his public examination, and the following spring took his degree for M.A. Upon thus completing his studies at the University, he returned home to Cracombe House, and the interesting character of the vicinity and surrounding country afforded him almost inexhaustible materials as a geologist. The district was at this time being opened up in the formation of railway cuttings, and these in the valley of the Severn afforded him opportunities for working out the then unknown relations of the Keuper and New Red Sandstone beds. His geological collection may probably be considered to have assumed a systematic shape about this time. It rapidly increased, and its arrangement and classification brought him into correspondence and acquaintance with men of kindred tastes and acknowledged reputations both at home and abroad. At the same time other branches of natural history occupied a large share of his attention, and his collection of birds assumed somewhat large proportions. His practical knowledge of the geology of Worcestershire enabled him to afford valuable information to Mr. G. B. Greenough in the construction of the second edition of his geological map. The same cause led to a knowledge of, and friendship with Sir Roderick Murchison, who in 1834 requested Strickland to lay down the boundary between the Lias and the New Red Sandstone in Worcestershire for the ordnance map then in progress. He had previously, in conjunction with Mr. Edwin Lees, furnished a geological map of Worcestershire to Sir Chas. Hasting's Illustrations of the Natural History of that country, which, when it is remembered that the field was at that time uncultivated and geologists knew little of the geology of the Malvern and Aberley range, may be regarded as a very carefully prepared and creditable piece of work. During one of the visits of Murchison to his father's house at Cracombe, he was accompanied by Mr. W. J. Hamilton, the secretary of the Geological Society, who was at that time contemplating an extensive expedition to Asia Minor. The discussion during the evening of Hamilton's project induced a desire in Strickland to accompany him, and shortly afterwards it was arranged that they should go together. They left in July, 1835, and from the time of starting Mr. Strickland kept a journal of all his transactions and wanderings. The natural features and geological formations of the countries visited formed the subject of several papers to the Geological and other learned Societies. His journal is full of entertaining and pleasantly-written narrative, with anecdotes and descriptions of many celebrated European philosophers of that time, and their museums and ways. The narrative is well worthy of perusal, but in a brief memoir, such as this, it is impossible to do more than mention it. The two friends passed nearly a year together travelling through the countries of Europe to Greece and Asia Minor. They also visited Constantinople, and spent some time on the island of Zante. From the latter place he returned by way of Malta to Naples, where he expected to receive letters from his father. In this, however, he was disappointed, but resolved to wait a few days and make the ascent of Vesuvius. On his way towards the summit, at the Hermitage, he was overjoyed to meet his father. It appeared that the letters of each had got astray, so that their whereabouts remained unknown. From Naples he travelled with his father through Italy, and in August joined his mother and sisters at Bex, in the Pays de Vaud. From thence the journey homewards was commenced. At Brussels his youngest sister was seized by fever, which terminated fatally in a few days. During his absence, his brother Algernon had also died whilst abroad with his vessel, so that the return to Cracombe was an extremely sorrowful one. After rest and gradual relief from the anxiety caused by the distress of his family, Strickland's mind gradually turned itself to the interesting objects around him, and his attention became chiefly directed to geology. The science was becoming increasingly important, and was cultivated by many ardent workers. The counties of Worcester and Gloucester were now intersected by railways, and their cuttings and excavations opened wide fields for observation. Sir Roderick Murchison was completing his Silurian system, and had already entered into that contest with Sedgwick and Buckland which was so often and long fought in the meetings of Section C at the British Association. Strickland's residence being located within one great area of the disputed ground, and Cambria lying at no great distance, constant appeals were made to him to verify sections by Murchison, and he entered into the subject with ardour. The subject would have been irresistible even if his previous studies had not prepared him for it, but previous to his Eastern expedition, geology occupied a foremost place in his mind, and finding so much more extensive opportunities on his return, his interest became still more engrossing. Sir Roderick was entirely at variance with Dr. Buckland as to the supposed analogy, or rather the identity of the red sandstone of Warwick with the Keuper. He looked upon the Gloucestershire marls and subordinate bands of sandstone as Keuper, and the sandstones of Broomsgrove and Warwick as Bunter Sandstein, Buckland regarding the latter as Keuper. It was to work out these details that Strickland set himself, and being so well situated for observation his knowledge quickly became greater than that of Murchison, and the latter proposed that they should write a joint memoir on the subject for the Geological Society. In was in this paper that the first mention is made of fossil footprints in the English Keuper. Strickland also communicated papers on the fluviatile drift of the Avon and of the Severn Valleys. His researches in this department were incorporated in the Silurian system. He found many fossils during his investigations and his collection was rapidly assuming a somewhat portentious extent.

In 1841, Strickland prepared a second edition of Murchison's Geology of Cheltenham, which is still a valuable guide to that interesting district. In 1837, accompanied by his father, he made a tour in Scotland, during which the material for his paper on some remarkable dykes of calcareous grit at Ethie, in Ross-shire, was collected. At the meeting of the British Association at Glasgow, in 1840, Strickland read his paper on the true method of discovering the natural system in zoology and botany, and after the meeting he paid a visit to Jardine Hall, the residence of Sir William Jardine, where he first met with the lady who was afterwards to be his wife. Sir William Jardine's large collection of birds greatly interested him, and various plans were formed for the future advancement of that branch of natural history. He also, at the meeting at Glasgow, read a paper on the vitality of seeds, in which the result of considerable investigation showed that the reported growth of wheat or other cereals obtained from Egyptian tombs must have been mythical. The reform of the nomenclature of zoology, as well as its classification, was a subject to which Strickland devoted a great deal of attention. The confusion and inconvenience involved by some systems recently invented were great drawbacks to the systematic progression of natural science, and Strickland, after carefully devising a plan, submitted it to many of the most learned authorities in this country and on the Continent. He received the approval of Prof. Owen, Mr. Darwin, and others in this country, and had a long correspondence with M. Agassiz at Neuchatel, and the Prince of Canino at Florence. Previous to the meeting of the British Association in 1842, at Manchester, the Council resolved that a Committee consisting of Mr. C. Darwin, Prof. Henslow, the Rev. L. Jennings, W. Ogilvy, Mr. J. Phillips, Dr. Richardson, Mr. H. E. Strickland (Reporter), Mr. J. O. Westwood, be appointed to consider the rules by which the nomenclature of zoology may be established on a uniform and permanent basis, the report to be presented to the Zoological Section, and submitted to its Committee at the Manchester meeting. To this Committee its members added the names of Prof. Owen, Messrs. Broderip, Shuckard, Waterhouse and Yarrell. This Committee considered Strickland's plan, and after making some amendations, a report was agreed to, with the exception of Mr. Ogilvy, and afterwards completed and given to the public. It created a good deal of opposition. Some modern inventors of names felt keenly the criticism of their views and compositions which the new scheme exposed. The opposition, however, did not assume a definite form, and after being thoroughly discussed, the report was printed in the transactions of the British Association for 1842, and distributed to the Academies and Natural History Societies throughout the world.

Expressions of satisfaction and congratulation poured in upon Strickland from all parts, and it must have been gratifying to him, after the serious efforts he had made, to find that his classification was almost universally approved. The report forms the basis for zoological nomenclature, and its axioms have been widely and decidedly acted upon. In 1842, Edward Forbes sailed with the Surveying Expedition of H.M.S. "Beacon," under the direction of Captain Greaves, to the Mediterranean, and Strickland afforded him the benefit of his knowledge derived from his journey in that district, and indicated to him the lines of research which might be followed out with advantage: these were of considerable use to Forbes during his investigations. A number of remains of fossil insects had been found in the lias of Warwickshire, and, in conjunction with the Rev. P. B. Brodie, he devoted considerable time to their identification and relationship.

He attended the meeting of the British Association at Cork, and contributed two papers, one on the Description of a Chart of the natural affinities of the incessorial order of Birds, and the other on the structure and affinities of Upupa, Linn and Irrisor, Less. The former exhibited the affinities of the allied organic forms diagramatically, and not only included the families and genera of the incessories, but showed their relationship to the whole class of birds. At the same meeting he was requested by the Committee of the Biological Section to draw up a report on the recent progress and present state of ornithology. This report was written and read at the next meeting at York, and published in the reports of the association for the year 1843. With it was included the recent fossil ornithology, and the existing knowledge of the dodo was summarised. The research in connection with the preparation of this report enabled Strickland to grasp more fully the desiderata in the classification and arrangement of birds. His collection also rapidly increased, and was supplemented by correspondents in all parts of the world.

It was in the year 1842 that Strickland mentioned to the Council of the British Association a project for forming a society for the publication of papers on natural history, which required illustrations rendering them too expensive for the ordinary proceedings of the learned societies. The proposal assumed a more definite form in

1843, when he drew up a sketch of a series of rules for that purpose, which embodied most of the principles ultimately agreed upon. This was the first origin of the Ray Society. The plan was afterwards developed by the activity of Dr. Johnson, of Berwick, a fellow-labourer and much-valued friend. In August, 1843, Strickland wrote to Sir William Jardine as follows :—" It is proposed to establish a Society, to be called the Montagu Society, for the purpose of publishing original illustrative memoirs on recent or fossil zoology and comparative anatomy ; the subscription to be £1 per annum ; the number of the subscribers to be unlimited ; each subscriber to receive annually a copy of all the publications of the Society, which are also to be sold, without restriction, at a reasonable price to the public. The Society not to accumulate capital, but to publish annually a greater or less amount of matter according to the state of its funds ; the illustrations to be confined to such objects as are either new to science or have been inaccurately or incompletely figured previously. The Society may, if thought advisable, present any of their plates or letterpress to the transactions of Scientific Societies, retaining a sufficient number of copies for distribution among their own members. Memoirs which have been already read to other Societies may be published by this Society, provided such memoirs have not been previously printed. Such was the outline of my proposed plan, the idea of which originated in the evidence which came before us at Cork, and the number of valuable researches which seem likely to remain in manuscript from the great cost of making engravings. There were " Forbes' Dredgings in the Mediterranean," Denny's "Entozoa," Alder and Hancock's " Nudibranchiata," Dr. Carpenter's " Microscopic Researches on Shells," and a host of other valuable communications, all appealing to the Association for help which the Association was obliged, from want of funds, to refuse, and it further appeared that most of the great Scientific Societies were equally unable to publish memoirs which required any great outlay of plates for their illustrations. A Society especially devoted to this object seemed to offer the only chance, and I rejoice therefore to see that such a project is likely to be at last realised." Dr. Johnson took up the projected Society and entered with much spirit into its organization. Much assistance was given by Bowerbank and Edward Forbes, and several other eminent naturalists of the time, but the real institution of the Society rests with Strickland, Dr. Johnson, and Sir William Jardine, each of whom wrote many hundreds of letters during the first year in organizing the Society. The new Society speedily increased in numbers, and was soon placed on a thoroughly good basis, and has continued to the present day to publish most valuable original papers, which have added greatly to the interest of zoological studies both in this country and abroad. The value of Strickland's plan, having regard to the existing forms of animal life, was proved by the geologists immediately starting a Society of their own on a similar basis and managed most successfully by nearly the same rules, and the Palæontographical has furnished to its subscribers a continuous series of volumes, beautifully and elaborately illustrated, of the greatest interest. Geographers were not far behind, and the name of Hackluyt is immortalized by another Society which has printed a series of voyages and travels that were before almost or quite inaccessible. Strickland's interest in the Ray Society was very great and one of the most useful of its works is due mainly to his zeal and energy. Professor Agassiz had commenced some time previously a compilation of a Bibliographia Zoologiæ et Geologiæ for his own private use, but it increased to such bulk and importance that its publication was rendered an object to be desired. M. Agassiz had frequently corresponded with Strickland with reference to this work and the institution of the Ray Society presented an opening which it occurred to the latter might be made useful to the Swiss naturalist, and at the same time advantageous and honourable to the Society. It was, therefore, proposed that the manuscript of Professor Agassiz should be purchased and published by the Society. Eventually, a sum of £300 was agreed upon as the price of the manuscript, a very considerable one to be incurred by so young a Society. The expenditure, however, was spread over several years, and the publication of the work was begun. The manuscript was set up in type and printed on large sheets and distributed to various naturalists for additions and corrections. The editing of the volumes occupied a large portion of

Strickland's time and attention even to his last days, for whilst the labours of Agassiz formed an excellent skeleton, innumerable additions had to be made before the work was complete. The first part consists of an enumeration of periodicals arranged geographically; the second part contains the names of authors arranged alphabetically, and a list of the works and memoirs of each. The first volume, of about 600 pages, only came down to the end of the letter B, and the whole work proved one occupying much time, and filling four large volumes. On its completion, the Ray Society passed a resolution to issue at intervals supplements which should continuously bring the work up to time. This, however, was never done, which is much to be regretted. The time that has passed since its issue will render the continuation, if it ever is done, very arduous and difficult.

Strickland's family removed in 1845 from Cracombe House to The Lodge, near Tewkesbury, near to the residence of his aunt, Miss Julia Strickland, who had now attained a considerable age, which rendered it advisable that some relative should be near for the management of the fine property connected with her residence, Apperley Court. On the 23rd of July of this year, Strickland married Catherine D. M. Jardine, second daughter of Sir William Jardine, Bart. The honeymoon was spent in Sweden, a country at that time not very much frequented, but which Strickland was anxious to visit in order to see the museums, and study the specimens in them. The journey proved a very pleasant one, and, as usual with him, a diary was kept of all his wanderings. At Haarlem he visited Prof. Van Breda, the Palæontologist, and at Utrecht Prof. De Jeude, who had charge of the geological museum. Another ornithologist, Dr. Hartlaub, was visited at Bremen. Profs. Nilsson, Lichtenstein, and other eminent scientists, received the English naturalist and his bride with every respect and kindness. On his return to England, after visiting his parents, he finally decided to settle down at Oxford. His large collections were greatly added to as the result of frequent rambles over the country of his new residence. His time was principally occupied in editing the Bibliographia for the Ray Society; writing a history of the Dodo; and in preparations for the meeting of the British Association at Oxford. The latter proved a very successful one, and a more real and vital interest in its proceedings was taken than had perhaps previously been the case. Shortly after the meeting, Dr. Buckland first exhibited signs of that mental decay which, during the latter period of his life, rendered it impossible that he should continue to occupy the position of Professor of Geology in Oxford, and after some time had elapsed and Dr. Buckland was unable to continue his lectures, it became a matter for consideration as to who should be appointed to fulfil the office. Dr. Daubeny, who was consulted upon the matter, suggested that either Lyell or Strickland was best qualified to occupy the chair, and eventually Strickland was elected, and accepted the appointment. At the same time Mr. Storey Maskelyne was placed in the Mineralogical chair. Dr. Buckland's versatility and knowledge had rendered geology popular at the University, and possibly still more so in the country. He worked at the subject with his whole heart, and explained many of those points which were beginning to render it unpopular by the supposed discordance with the records of the Bible. But his gifts had done little at this time to change the University prejudices in favour of classics and mathematics, and he could only induce a few men to join his pursuits and attend his lectures. On Strickland's acceptance of the position of Reader of Geology he immediately devoted himself to the preparation of his course of lectures, and delivered an opening address on the studies of the University of Oxford. The succeeding lectures of the first course were on the chronology of the ancient earth, and were introductory to the general subject to be treated upon in future lectures. His second course in the year 1851 was on volcanic phenomena, the elevation of mountains, and other disturbances affecting the earth's crust, the principles of geology, and the earlier stratified deposits, followed by a third on the succession of the secondary and tertiary formations. The whole course would have been completed, had he not met with a premature death, by the history of the tertiary and recent epochs. His lectures were illustrated by numerous diagrams, in many cases prepared by his wife, who was an excellent draughtswoman. Strickland was always ready to communicate information, and frequently lectured for different institutions. The Tewkesbury Mechanics' Institution, the Natural History

Society of Worcester, and other kindred bodies, knew him well. He frequently conducted the members of societies to the field, and explained, by open-air lectures, the geology of the country around, and in a variety of ways extended a knowledge of geology amongst the people. His connection with the University, his public vocations, and private scientific pursuits, together with the exercise of his duties as a country gentleman and magistrate, which began gradually to fall upon him, with occasional excursions before or after the meetings of the British Association, fully occupied his time.

In September, 1853, he attended the British Association with his father-in-law, Sir William Jardine. The meeting was below the average in numbers, but was otherwise an interesting one. Professor Sedgwick presided over the Geological Section. Strickland occupied the chair during some portions of the meeting as a vice-president, and he contributed a paper on pseudo-morphous crystals in new red sandstone. To the Zoological Section he read a notice on the mode of growth of Halichondria suberea, and another on the partridges of the great watershed of India. On the Saturday he joined an excursion under the charge of Professor Phillips to Flambro' Head. This was Strickland's early country, always familiar to him, and remarkable sections, well known, were in their turn pointed out. The walk was much enjoyed, and at the termination of the cliffs the Speeton clay was inspected. Some of the party walked on to Scarborough, others returning to Hull. The next week the business of the Sections was resumed and the meeting terminated in the usual way. After its close, Strickland was anxious to examine the cuttings in the Manchester Sheffield and Lincolnshire Railway, near Retford, in reference to which some discussion had taken place in the Geological Section. For this purpose he left the train at Retford, intending to join a succeeding one at Gainsbro'. He walked along the line to a point near Gringley Balk Bridge, where there is a pretty sharp curve. "Here two trains were coming up in opposite directions, the one a coal train, which was seen, and to avoid this he stepped upon the other side, on which an unseen passenger train was approaching round the curve at a speed of 25 or 26 miles an hour, at a distance from him of less than one hundred yards. The driver of this train reversed his engine, put on brakes, and whistled loud and very alarmingly, 'but he took no notice, his attention seemed to be on the coal train.' Death must have been instantaneous. There could be no pain, not even a momentary feeling of alarm or fear. The double noise gave no warning of the engine behind, and he was struck, unconscious of danger, and not even turning from his watching of the other receding train." These are the simple facts as recorded by Sir Wm. Jardine in the work already referred to. His remains were deposited in the graveyard of Deerhurst Church, between Tewkesbury and Gloucester, in the family vault. His entire ornithological collection was presented to the new museum of the University of Oxford, under the condition of being always open for scientific consultation, and a large number of specimens and skeletons, illustrating the comparative anatomy of birds, were presented to the museum at Worcester.

NOTES ON BRITISH EOCENE POLYZOA. BY GEORGE ROBERT VINE.

PLATE V.

In the early part of 1887 Mr. G. W. Shrubsole, F.G.S., of Chester, made over to me, for description or otherwise, a slide of London Clay Polyzoa. This slide contained five specimens, comprising four species at least, and I believe that it represented the whole of the Polyzoa discovered by his brother when investigating the prolific London Clay fauna of Sheerness.

In addition to this series I have my own private collection which has been accumulating for years, but unavoidably slowly, and I have also had the advantage of studying collections from the Isle of Wight beds, which form parts of the private collections of others I am also indebted to Prof. T. Rupert Jones, F.R.S., Charles D. Sherbon, and Alfred Bell, Esq., either for the gift, or loan, of Polyzoa derived from various Eocene horizons.

In 1850 William Lonsdale published, in Dixon's "Geology of Sussex," descriptions of four species of Eocene Polyzoa.

1. Eschara Brongniarti? M. Edw., Tab. i., fig. 9.

2. Cellepora ? petiolus, Lonsd., Tab. i. fig. 10, p. 151.
3. Lunulites urceolata ? Lamk., Tab. i , fig. 8, and
4. Idmonea coronopus Defrance, Tab. ix., fig. 24, p. 153.

As these will be referred to again further on it will be useless to make remarks on the species.

In Morris' catalogue of British Fossils (1854), and also in the Palæontological part of Jukes's "Student's Manual of Geology" (1857), the following species and their horizon are indicated :—

1. Flustra crassa, Desm. London Clay: Primrose Hill.
2. Eschara Brongniarti, Lonsd. ,, ,, ; Bracklesham Bay.
3. Cellepora petiolus, Lonsd. Mid-Eocene, Bracklesham.
4. Lunulites urceolatus, Lamk. *Coscinoporis pileolus*, Phill. and Wood, Mid-Eocene, Bracklesham.
5. Idmonea coronopus, Defr. Mid-Eocene, Bracklesham Bay.

In 1866 Mr. George Busk, F.R.S., published in the Geological Magazine (Vol. iii., p.p. 298-302), a description of "Three species of Polyzoa from the London Clay at Highgate, in the collection of W. T. Wetherell, Esq., F.G.S." The plate containing the figures were drawn, but never published, by J. De Carle-Sowerby, and this, with the figures of Lonsdale in Dixon's Geology of Sussex, are the only illustrations of British Eocene Polyzoa that I am acquainted with. As regards the literature three other references will complete the list also.

In Phillip's work on the Geology of Oxford and Valley of the Thames (ed. 1871), I find the following reference. After giving a rather full list of Polyzoa, ranging throughout the whole of the Cretacious epoch (pp. 434-436), the author refers briefly to the Eocene strata within the drainage of the Thames, and Polyzoa are mentioned, but genera only, no species are given.

Horizon : London Clay : *Cellepora*, *Crisea ?* and *Eschara*.
,, Thanet Sands and Woolwich beds. *Flustra? Lunulites*.

In the "Catalogue of Tertiary Fossils" in the School of Mines (1878), I find references to the following species only :—

Flustra crassa, Desm. Thanet Sands, p. 7.
,, sp. Woolwich and Reading beds, p. 10.

Flustra crassa, Desm. London Clay, Highgate, p. 14.
Polyzoon ,, ,, Sydenham, p. 14.

In my "British Association Report on Fossil Polyzoa (1884-5), and also in the supplementary part of the Report on Recent Polyzoa" (1885-6), I referred to, and gave all that was known of the Fossil species, and a full reference, as far as I was able to at the time, of foreign horizons of Eocene and Miocene Polyzoa.

When compiling material for the Tertiary division of my British Association Report on Fossil Polyzoa (5th of the series), relying upon a general experience of the subject, I naturally suggested that the poverty of a British Eocene Polyzoa fauna may be ascribed to want of research rather than to a positive absence of forms. My suggestion was futile, and I have learned since that Eocene Polyzoa is indeed scarce, both in this country and on the continent. My friend, Mr. Bell, writing me on the subject, goes into the question rather fully, and as there is a scientific value in his remarks I cannot forbear quoting and endorsing his views.

"Considering the richness of other sections of organic life in the Eocene, the great poverty of the Molluscoida: Brachiopoda and Polyzoa, is very remarkable, and this poverty does not arise from an oversight on the part of collectors, or for want of looking for. Some thousands of specimens having passed through the hands of one or other of us, it is possible to speak with some amount of certainty upon this head. Of the few species listed, *M. Lacroixii*, *Flustra crassa*, and *Lunulites urceolatus*, are the commonest, but are by no means abundant; and the first two have a wide range in Eocene time. Neither do they occur in any quantity in the Continental Eocene fauna, as an examination of some thousands of shells from the Paris basin will expose an equal sparseness.

The cause of this absence is difficult to explain, as far as the free-growing Cyclostomata are concerned, unless that the soil, or food, or other conditions of life, was not favourable for their development. For the adnate Cheilostomata, the want of such shells or adherent surfaces proper for their habitat may be sufficient cause.

Reasoning from the rich Crag fauna, it would appear that Polyzoa require certain genera of Mollusca, and only certain species of these are selected, dead shells and shell banks among the bivalves especially being in demand, *Pecten opercularis* and *P. Gerrardii: Pectunculus, Cytherea rudis, Pholas, Solen, Tellina crassa* and *obliqua, Fusus antiquas, Nassa* and *Collumbella*. Other genera are less so, and of these *Fissarella, Capulus, Buccinum, Purpura tetragona, Ostrea*, and *Cardium*, are the chief. Terebratulæ are good hunting grounds in the Coralline, but not in the Red Crag. With the exception of *Solen, Pectunculus*, and others, these genera are rare, or at least numerically so, individually in the Eocenes, and of these it may be said that very few examples are known in a worn or "dead" condition. Drifted shell banks are not common. Most of the species are in their native haunts, or where they have been removed, the genera, such as *Cyprina*, are not those selected for attachment.

The conditions of life again are not favourable: the Eocene of England consisting of either sharp sand or muddy clay, estuarine or fresh water beds.

Sharp sand is also unfavourable for preservation, as in the case of the Oldhaven sand at Bromley, where the *Pectunculi* are in millions, with the surface nearly all decorticated, and in the London Clay, casts of the shells are alone preserved (save a few portions of the test) in a pyritised condition.

There is only one other reason I can suggest for their absence, *i.e.*, that the Molluscoida had reached their apogee in the Cretaceous period, and only few genera and individuals represented this class of organisms, till other times and conditions more favourable to their existence came in, in other words, they were non-existent."*

In the following monograph, for the sake of future students, I have collected together all that is known respecting the few Eocene species, but whenever I could I have corrected the older work by references to my own and the loaned collections; the new species and varieties are additions to all previous lists, and described from examples in my own cabinet.

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* **Brit. Assoc. Report on Recent Polyzoa, 1885-6, p. 192 of Report.**

	Genera and Species.	Thanet.	London Clay.	Bagshot and Bracklesham.	Barton.	Oligocene.	Recent.	My own Cabinet.
	Cheilostomata, Busk.							
1	Dittosaria Whetherellii, Busk		×					
2	Membranipora Lacroixii, Aud,		×	×		×	×	v
3	„ ? crassa, Desm.	×	×					v
4	Biflustra eocena, Busk			×				
5	Diachoris intermedia, Hks.			×			×	
	Membraniporella nitida, John						×	
6	„ var. eocena		×					v
	Microporella violacea, John.						×	
7	„ var. (a) fissa, Waters		×	×				v
	„ var. (b)		×					
8	Eschara ? Brongniartii, M. Ed.		?	×				v
9	? sp.			×				v
10	Cellepora petiolus, Lonsd.			×	×			v
11	„ sp. (pumicosa ?)		×				×	
12	Lunulites urceolata, Lamk.			×	×			v
	Cyclostomata, Busk							
13	Crisia sp. (eburnea ?)		×				×	
14	*Idmonea coronopus, Def.		×	×			?	v
15	† „ gracillima ? Reuss		×					v
16	Hornera (minuta ? sp. n.)			×				v
17	„ flabelliformis ? Blainv			×				

* I. Atlantica ?
† Allied to if not identical with Reuss's species.

DESCRIPTION OF SPECIES.*

Generally I have followed the classification of Mr. Hincks in British Marine Polyzoa. Some of the species, however, especially those adopted from Mr. Busk and Mr. Lonsdale, I have allowed to remain under the generic terms adopted by these respected authors.

Sub-Order CHEILOSTOMATA Busk.

Family GEMILLARIDÆ Busk.

Genus, DITTOSARIA, Busk.

1866. Polyzoa of the London Clay, Geol. Mag., vol. III., p. 3.

Zoarium rigid, calcareous, dichotomous. *Zoœcia* adnate by the back, and throwing out a double cell at each dichotomy.

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* NOTE.—Nearly the whole of the species of Eocene Polyzoa referred to in this paper have been figured, and the reader will find at the end ample descriptions of the plate v.

1. DITTOSARIA WHETHERELLII, Busk. Geol. Mag., vol. iii., p. 4, pl. xii., fig. 3.

Allied to *Gemellaria loricata*, but the orifice of the Zoœcia is much smaller and nearly round. Mr. Busk says that "the wall of the cell is sparsely punctured so as at first sight to suggest a suspicion that the species may belong to the cyclostomatous sub-order, but close examination of the orifice will show, I think, signs of the articulation of an operculum, were not the ventricose form of the cell itself a sufficient indication of the true place of the species."

Habitat: On Stone?

Horizon: London Clay, Highgate. Collection of N. T. Wetherell.

Family MEMBRANIPORIDÆ.

2. MEMBRANIPORA Lacroixii, Busk. Geol. Mag. vol. iii., 1866.
,, Lacroixii, Savigny, Egypt. pl. 10, fig. 10.
,, Lacroixii, Busk, B. M. Cat. p. 60, pl. 69.
,, Lacroixii, Hincks, B. M. Pol. p. 129, pl. xvii.
Flustra distans, Hassall, Johnston.
,, Peachii. Couch.
Conopeum reticulum, Gray.

There are in the Eocene rocks fragments of a species of *Membranipora* allied to, if not identical with, this widely distributed form. Mr. Busk, in describing three species of Polyzoa from the London Clay at Highgate,* says, "I am unable to perceive any essential difference between the form here represented and the existing species (*M. Lacroixii*). . . . In general aspect and mode of growth, . . . the two agree very closely. The only distinction I am able to draw between the Eocene and recent form, as exemplified in a specimen now before me, collected by the late Mr. W. Thompson, of Belfast, at Portmarnoch, consists in the somewhat greater thickness of the septa in the former. The two agree also in the circumstance that in the septa of the more worn cells there is an appearance of minute distant pores, which is quite in accordance with the existence in very perfect specimens, of extremely delicate marginal spines.

Habitat: On Shells and Stones, &c.

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* Geol. Mag. 1866, vol. iii., p. 2.

Horizon: Oyster beds, Colwell Bay (Prof. Judd); Bracklesham beds, Isle of Wight; London Clay: Walton-on-Thames (C. D. Sherborn); Highgate.

In examples of the above species from Colwell Bay, especially whenever the sides of the cells are exposed, the delicate communication pores, three in number (Rosettenplate), are seen to perfection, much better preserved and less calcified than in some of the more recent specimens in my possession.

3. MEMBRANIPORA ? CRASSA, Desmar.

Flustra crassa, Desm., of authors.

I only know the species by a poorly preserved example which I should not care to attempt a description of. As the species is quoted in School of Mines Catalogues it may be well to retain it in the list of Eocene Polyzoa.

Horizon and *Locality:* Thanet Sands; London Clay, Highgate; (School of Mines collection.)

4. BIFLUSTRA (MEMBRANIPORA) EOCENA, Busk.

= Biflustra eocena, Busk, Geol. Mag. vol. iii., p. 3, pl. xii., fig. 2.

Zoarium irregular, infundibuliform. *Zoœcia* oblong, arched above; septa granular, double: aperture sub-oval or rounded, the lower border thickened, granular.

Horizon and *Locality*: London Clay, Highgate.

In a memoir "Les Bryozoaires du Systeme Montien, (Eocene inferior),"* the authors describe a very beautiful species under the name *Biflustra symmetrica*, in the Zoarium of which the cells are much better preserved than in our own. The areas are rather more elongated than in *B. eocena* and the septa well granulate. Not much detail can be got from the London Clay example, as, being embedded in a mass of Septaria the Zoarium and Zoœcia, have suffered in consequence.

5. DIACHORIS INTERMEDIA, Hincks.

1881. = D. intermedia, Hks., Ann. Mag. Nat. Hist., Aug., p. 133.

1885. D. intermedia, Waters; A. Bell, Brit. Assoc. Rep. p. 195.

Quoted by Mr. Bell in the Eocene list supplied to me while the Report on Recent Polyzoa was passing through the press.

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* A. Meunier and Ed. Pergens Louvain, 1886.

Horizon : Bagshot Beds, Isle of Wight.

I have no knowledge of the Eocene example of this species. Those examples described by Mr. Hincks in 1881, of which *D. intermedia* was one, were Australian forms generally ; *D. intermedia* is from Tasmania.

Family Cribrilinidæ, Hincks.

Genus Membraniporella (part) Smitt.

1880. Hincks, Brit. Mar. Polyzoa, p. 199.

For remarks on this beautiful genus, which in the Brit. Marine Polyzoa follows the *Cribrilina* group, see the above. "*Membraniporella* is strictly a transitional form ; but as its spines, in the adult condition, are so modified as to form a front wall which rises above the margin and roofs in the area, its place would seem to be amongst the Cribrilinidæ." Species of the genus have a very wide geographical distribution, but I have no fossil range to refer to.

Membraniporella nitida, Johnston. See Hincks, Brit. Mar. Polyzoa, p. 200.

The range of variation in this species is so great in recent examples that I hardly care to create a new specific name for this Eocene form.

6. Membraniporella nitida, Johnst. Var. eocena, var. n.

As in recent species the front of the *Zoœcia* is disposed in lines, varying from twenty to twenty-six (10 or 13 on each side of the midrib) in number. Unlike *M. nitida,* the lines at the base of the Zoœcia, eight in number, are formed after the manner of *M. melolontha*, Busk, but the cells are contiguous, not produced. Hincks says nothing about punctures in these flattened ribs, but in the eocene variety there are from three to four in some of the horizontal ribs. Otherwise the description of the recent species in Brit. Mar. Polyzoa will serve for this variety as well as regards the *Oœcia, avicularia* and general outline of the Zoœcium.

Horizon: London Clay, Isle of Sheppey (discovered by Mr. Shrubsole).

In my own cabinet I have several recent examples of *M. nitida* from Guernsey and the Red Sea, and so variable is the ornamentation of the species that one naturally hesitates increasing the nomenclature of the species. The arrangement of the ribs at the base of the cell is sufficiently distinctive of the variety.

7. MICROPORELLA VIOLACEA, Johnst. Var. (*a*), FISSA, Waters.

1880. Microporella fissa, Hincks. Contrib. Gen. Hist. Mar. Poly. Ann. Mag. Nat. Hist. Ser. 5, vol. vi., p. 381, pl. xvii., f. 4.

1881. Microporella violacea var. fissa, Waters. Quar. Jour. Geol. Soc., vol. xxxvii., p. 329, pl. xv., fig. 26, pl. xvii., f. 73.

Mr. Waters describes in his "Fossil Chilostomatous" Boyozoa from S. W. Victoria, Australia, a peculiar variety of the widely distributed *M. violacea.* The *Zoarium* is *Eschara-form*, flat and depressed. *Zoœcia* pyriform or oval, much raised, surrounded by a row of pores, or in old and worn cells covered with pores. The peculiar character of the Zoœcia of *M. violacea* will be seen if the student will refer to Brit Mar. Polyzoa, vol. ii., pl. xxx., figs. 1 and 2, and in *M. plagiopora*. var. *b*, the Crag form of *M. violacea* in the same plate. Intercallery cells, much smaller than the regular Zoœcia, are shown in fig. 4.

The London Clay variety of *M. violacea* seem to combine all the variations pointed out by Mr. Hincks and Mr. Waters in their description of *Lepralia plagiopora*, Busk, and *M. violacea*, var. *fissa*, Waters.

Var. *b*. There is still another variety of this species in my collection, but I have not sufficient material at my disposal to venture on a wider separation. This is *Eschara-form* like the *fissa* variety, but the Zoœcia are smaller and the slit beneath the small pore, either entirely absent or less pronounced, the front of the cell being almost or entirely punctate.

Horizon and *Locality:* Bracklesham beds, Isle of Wight.

8. ESCHARA ? BRONGNIARTII, M. Ed.

1836. Eschara Brongniarti, M. Ed. Ann. des Sc. Nat. 2nd series, lvi., pl. xi., figs. 9-9*b*.

1838. ,, ,, M. Ed. Rech. sur les Polypes, and sur Eschares fossiles; Paris basin.

1850. ,, ,, ? Lonsdale. Geol. Sus., Tab. 1, figs. 9-9*c*

Zoarium foliaceous. *Zoœcia* symetrically placed in the opposite layers, not overlayed at either extremity, pear shaped, bounded by a row of foramina; surface area small, nearly solid; mouth in same plane with surface large, semioval, curved margin, slightly raised, straight or proximal margin flat, slightly inclined inwards; "one or two foraminated vesicles at proximal angles of mouth;" interior of cells nearly similar in shape to exterior; lateral connecting foramina numerous near base of wall, terminal two; dorsal surface of opposite layers not separable, extremely thin; walls of adjacent cells separable, glossy but uneven.

Horizon: Bracklesham beds, Isle of Wight (Mr. Bell's collection).

I have no doubt but that the fragments in my cabinet belong to this species, as they answer the very full description of Lonsdale, but it is to be hoped, after the publication of the present monograph, that more attention will be given to the collection of Eocene Polyzoa.

9. ESCHARA sp.

There is a fragment of a species of Eschara (?) in my Eocene collection, which for the present I leave as above, as I am unable to identify it. The form is quite distinct from all others that I have described.

Horizon: Brackleshem beds, Isle of Wight.

10. CELLEPORA PETIOLUS, Lonsdale.

1850. Cellepora? petiolus, Lonsd. Dixon's Geol. of Sussex, p. 151, pl. i., f. 10.
1854. C. petiolus, Lonsd. Morris' Catalogue.
1867. Orbitulipora petiolus, Reuss. Über, Bryoz. aus dem deutsch Unteroligocän, p. 217.
? „ Haidingeri, Stol oligoc. Bryoz. v. Latdorf.
1878. Cellepora petiolus, Lonsd. Catalogue School of Mines.

Zoarium, disc-shaped, attached by a short cylindrical hollow pedicle, situated on the edge of the disc. *Zoœcia*, in opposite layers, but without intermediate laminæ; rows in each layer radiating from the centre, irregularly alternate; cells globular, peristome prominent, bounded by a deep groove; orifice round or slightly oval. *Oœcia*, large, semi-globular, covering the proximal portion of the cell; "affecting more or less the size of the cellular mouth opening into vesicle within the cell." Surface sometimes provided with a minute tubercle near distal edge.

Horizon : Barton beds ; Whitecliffe Bay ; Bracklesham ; Stubbingdon.

This seems to be the most abundant form of all the Eocene Polyzoa, as I have examples from all the above localities. In some of the masses of Bracklesham Clay, in the soaking of the mass, at least a dozen specimens may be obtained in very perfect condition. The Whitecliffe Bay forms are much better preserved.

11. CELLEPORA sp. (pumicosa ?) (Geol. Mag. vol. iii., p. 4.

Among Mr. Wetherell's collection Mr. Busk found "a very minute *Cellepora*, resembling some of the minute globular specimens of *C. pumicosa*."

Horizon : London Clay, Highgate.

Family SELANARIDÆ, Busk, 1853.

= Fam. Asterodiscina, Lonsd. Dixon's Geol. Sus.

11. LUNULITES URCEOLATA, Lamk.

1816. L. urceolata, Lamk. Animx. Sans Vert. t. ii., p. 195.
1836. ,, ,, M. Ed., t. ii., p. 300.
1850. L. urceolata, ? Lonsd. Dix. Geol. Sus., p. 159, pl. i. f. 8.
Not GOLDFUSS, nor LAMOUROUX.

Zoarium obtusely conical. *Zoœcia* in parallel rows, easily separated; form irregularly hexagonal or imperfectly oval; surface open, margin sharp, interior rounded, puctured by a few minute foramina; distal extremity slightly overlying, walls between the rows smooth. Thickness of Zoarium slightly exceeding the depth of the *Zoœcia*. *Vibracula* (= Intermediate chambers, Lonsd.) in linear series, lozenge shaped, and variable in size. Concave surface ribbed, foraminated.

Horizon : Barton, and Bracklesham beds, Isle of Wight.

My Barton beds examples are mere fragments, but the vibracular cells are distinct and characteristic.

Sub-Order CYCLOSTOMATA, Busk.

Fragments of species belonging to this Sub-Order are very rare, and sometimes ill preserved, but they form, nevertheless, a very pretty group of Eocene Polyzoa.

12. CRISIA EBURNEA ?

1871. Crisia ? Phillips' Geol. of Oxford and Valley of the Thames.

1886. = Crisia sp. Alfred Bell.

A small fragment of *Crisia*, probably belonging to *C. eburnea*, is all that I have a note of, as indicating the existence of species of this group in Eocene rocks.

Horizon: London Clay. (Phillips)

Crisia eburnea, in fragments of course, have been found in Post Pliocene rocks, Montreal: British Palæolithic: Scotch Glacial deposits: Austro-Hungarian Miocene. I have also found fragments in Australian Yarra-Yarra material.

13. IDMONEA CORONOPUS, Defrance ?

1850. Idmonea coronopus, Lonsd. Dixon's Geol. Sus. p. 153, pl. ix., f. 24.
(Idmonea Atlantica ? Forbes), Busk, Hincks.

Zoarium dichotomously branched; branches diverged excentrically, more or less rounded on the back; transverse rows of tubular Zoœcia, blended along the medial line, forming a crest; erect, less in height than the depth of reverse portion of branch.

Horizon: Bracklesham beds, Isle of Wight.

The species described by Defrance is placed both by Busk* and Hincks† as synonyms, though doubtfully, of Idmonea Atlantica, Forbes.

The *I. Atlantic* of the Post Pliocene beds of Garvel Park especially, is a most variable species, but whether it reaches back to the Eocene beds is rather doubtful; still beyond this I must admit that the fragments in my possession help to favour the references of Busk and Hincks. I think it wise, however, for the present to leave it where Lonsdale placed it.

15. IDMONEA GRACILLIMA, ? Reuss.

1869. Palæont. Stud. Tertiar. d. Alpen., pl. xxxv., figs. 1-2.

There are fragments of *I. gracillima*, Reuss, amongst the "Bryozoenschichte von Montecchio Maggoire," which closely resemble the species which I place here rather doubtfully. I cannot give many details of the British example, but while comparing specimens of the North Italian form I could not help noticing a resemblance, though

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*** 1875. Pt. iii. Brit. Mus. Cata. Busk, p. 11.**

† 1880. Brit. Mar. Poly. Hincks, p. 451.

faint, between these and the British example. Mr. Busk had a small fragment of *Idmonea* in the Wetherell collection, but he did not attempt identification on account of its imperfection.

Horizon: London Clay, Sheppey.

16. HORNERA sp. (minuta sp. n. ?)

One single fragment of a species of Hornera, resembling some of the minute dichotimous forms found in the Crag, but I cannot identify it as belonging to any of these, it is well however to preserve the record. Zoarium flattened at the base where it has been attached to some foreign body, arising from which are two minute branches having cells, about six in number.

Horizon: Brackleshem beds, Isle of Wight.

17. HORNERA sp. (FLABELLIFORMIS ? Blainville).

Amongst Mr. Alfred Bell's collection is a specimen of a flat, branching, flabelliform *Hornera*, probably referable to *H. flabelliformis*, Blainv. = ? *H. Ferussacii*, Michelin (Eocene and Miocene), but unfortunately none of the cells are exposed. The face is buried in a matrix of clay, but it is the largest example of all the Bracklesham Polyzoa, and if I were to attempt the washing of it the whole symmetry of the form would be destroyed. It is possible that free examples of this species may be found if carefully looked after.

Horizon: Bracklesham beds, Isle of Wight.

These are the whole of the true Eocene species that I am acquainted with. In higher beds, however, Mr. Bell assures me there is to be found at times fragments of rock derived from the earlier. In a note he says, "Looking over a parcel of stuff from the Post-Tertiary deposit of Selsey, in Bracklesham Bay, I came across the enclosed. It appears to me to be of Eocene origin." The material itself, a piece of fine sandy conglomerate in all probability was derived, but it was encrusted by Polyzoa, a very fine specimen of *Lepralia Pallasiana*, Moll.

In space this species has a wide geographical range; in time it *reaches* back to the Coralline Crag.

FOREIGN EOCENE POLYZOA, Calcaire grossier.
= Bracklesham beds, Lyell.

The following species from the "Calcaire grossier de Mons," have been described and partly figured by A. Meunier and Ed. Pergens.* The probable horizon of the Calcaire grossier rocks are on a line with our Bracklesham beds according to Lyell, but are characterised as "Eocène inferieur" by the authors. The number of fragments on which observations and identifications were based amounted to between 500 and 600, out of which about 31 species were identified, but only 24 are described. The others are reserved for further identification.

The list will be valuable to students of the Polyzoa fauna of our Eocene Rocks. Besides the Polyzoa there were a fine series of Ostracoda and Foramnifera, and although Polyzoa are rare, comparatively, in the Bracklesham beds, Ostracoda and Foramnifera abound in the finer *debris* of the clay, but I cannot say to what extent. Foramnifera (about 60 species) are abundant as individuals in the London Clay of Sheppey.

POLYZOA (= BRYOZOA, of Authors)

Sub-order, CHEILOSTOMATA, Busk.

Family CELLULARIDÆ.

1. Cellularia diplodidymioides, Meu. and Perg.

Family CELLARIDÆ.

2. Cellaria mucronata, M. et Perg.
3. ,, vandenbroecki, M. et Perg.
4. ,, hians, Reuss = Vincularia hians, Rss.

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5. Planicellaria eocena, M. et Perg.

Family MEMBRANIPORIDÆ.

6. Membranipora subtilimargo, Rss.
7. ,, symmetrica, M. et Perg. = Biflustra.
8. ,, angulosa, Rss.
9. ,, gothicâ, M. et Perg.
10. ,, oblonga, D'Orb.
11. ,, squamosa, M. et Perg.

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* Louvain, 1886.

Family MICROPORIDÆ.

12. Micropora gracilis, Munst. sp.

Family MICROPORELLIDÆ.

13. Bactridium Hagenowi, Rss.

Family MYRIOZOIDÆ.

14. Schizoporella phymatopora, Rss.

Family ESCHARIDÆ.

15. One species of Eschara only, found in the material.

Family SELENARIDÆ.

16. Cupularia Houzeaui, M. et Perg.

Sub-order, CYCLOSTOMATA, Busk.

Family TUBULIPORIDÆ.

17. Tubulipora plumula, Rss.
18. ,, dimidiata, Rss.

Family ENTALOPHORIDÆ.

19. Pustulopora Corneti, M. et Perg.
20. Entalophora montensis, M. et Perg.

Family IDMONEIDÆ.

21. Idmonea concava, Rss.
22. ,, gracillima, Rss.

Two other species of *Idmonea* are in the Author's possession, but names are reserved for more complete identification.

Family LICHENOPORIDÆ.

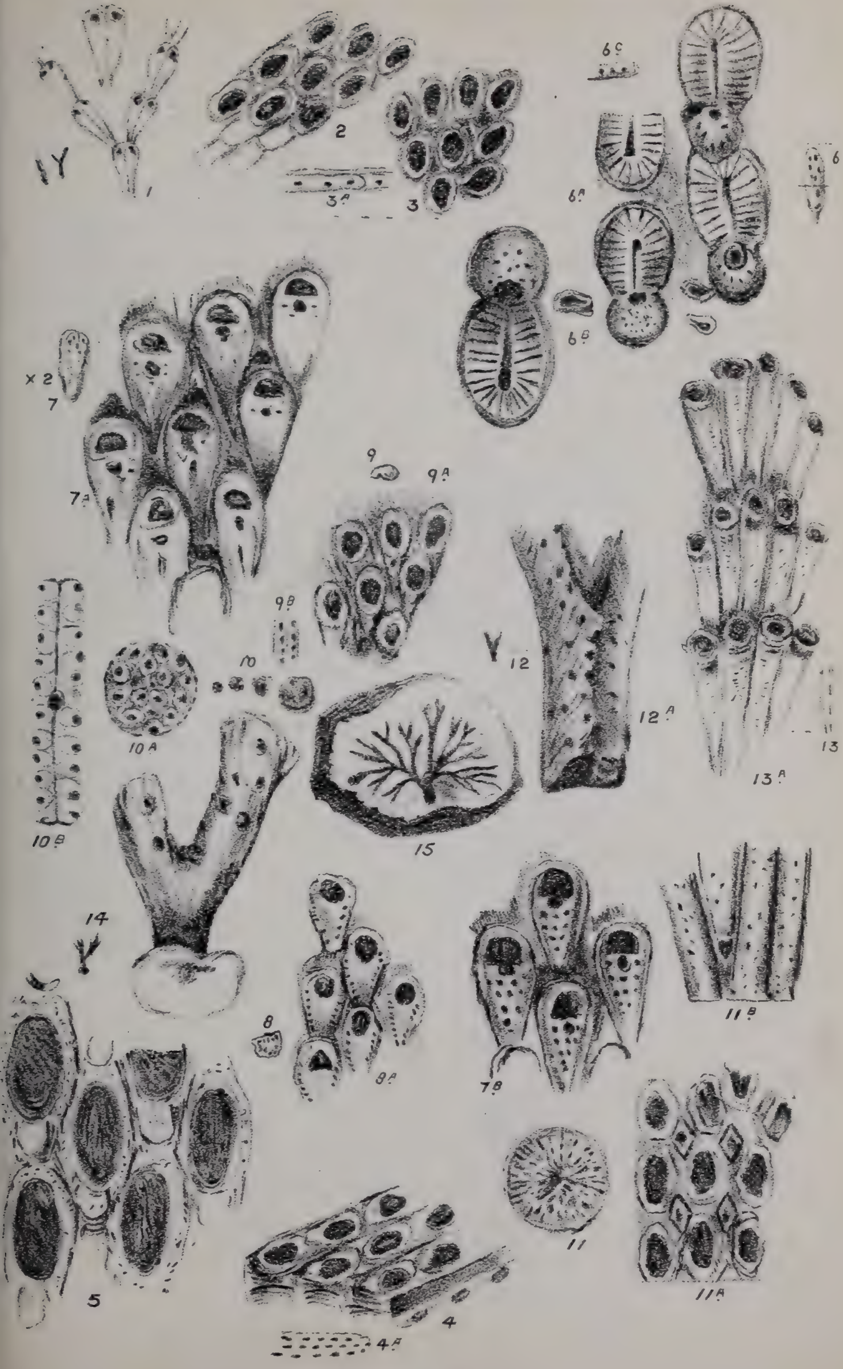
23. Discoporella Grignonensis, M. Ed.
24. Lichenopora Defranceiana, Mich.

DESCRIPTION OF FIGURES. PLATE V.

(See Text for Localities, &c.)

1. Dittosaria, Wetherellii, Busk. Natural size and enlarged.
2. Membranipora Lacroixii, Busk. London Clay, Highgate.

Proc. Yorksh. Geol. & Polyt. Soc., Vol. XI., Pl. V.



Vine: Eocene Polyzoa.

3. Membranipora Lacroixii, Busk. 3*a*, Communication pores in side walls. Up. Eocene, Colwell Bay.

4. Biflustra eocena, Busk. 4*a*, Natural size of fragment.

5. ,, symmetrica, Meu. et Pergens. Foreign example.

6. Membraniporella nitida, var. eocena, n. var. Natural size.

6*a*. ,, ,, Four cells from about the middle of colony, showing Oœcia and avicularia, one cell reversed as in the colony.

6*b*. ,, ,, Zoœcia, rather more perfect, with Oœcia and avicularia. 6*c*, dotted bar.

7. Microporella violacea, var. fissa, Waters. Colony magnified about twice.

7*a*. ,, ,, var. a. A few cells magnified to show character.

7*b*. ,, ,, var. b.

8. Eschara ? Brongniartii, M. Ed. Natural size and enlarged, 8*a*.

9. Eschara ? (Membranipora ?) sp. 9-9*a*. Natural size and magnified; 9*b*, to show the Escharaform character of example.

10. Cellepora petiolus, Lonsd. Four examples, showing the variety of size in this peculiar species, which in the Bracklesham beds are most abundant. Examples vary much from size of figures to nearly ½ inch in diameter.

10*a*. ,, ,, A small colony enlarged.

10*b*. ,, ,, Side view, showing point of attachment.

11. Lunulites urceolata, Lamk. Fig. 11*a*. A few cells with lozenge-shape avicularia, 11*b* reverse.

12. Idmonea coronopus (Defr.) Lonsdale. Natural size and magnified.

13. ,, gracillima, Reuss. Natural size, and side view enlarged.

14. Hornera sp. (minuta sp. n. ?) Unique.

15. ,, (flabelliformis ? Blainv.) The whole of the colony depicted; enlarged about 1½ times; embedded in matrix, reverse only; branches flat, striated, and slightly rounded or angular.

NOTES ON THE DRIFFIELD AND MARKET WEIGHTON RAILWAY.

BY REV. E. MAULE COLE, M.A.

The construction of a new railway, however small, affords opportunity for fresh geological sections. In the present instance the line is only 13½ miles long, and presents no new features, but it is interesting in some respects, especially at its western end, where it shows the position of the chalk as regards the underlying beds.

It was pointed out long ago by Phillips that a sub-cretaceous anticlinal existed somewhere about Garrowby, stretching east and west, which seemed to cut off the Oolitic rocks in North Yorkshire from those southwards about Market Weighton, but whether these rocks were removed by denudation previous to the deposition of the chalk, or thinned out against an old submarine shore-line was doubtful. The question is by no means settled yet, but the facts are these : the Lower Calcareous Grit and Oxford Clay of the Middle Oolites make their last appearance from the north at Hanging Grimston, near Acklam. The estuarine sandstones of the Lower Oolites share the same fate, except for a small patch at Kirby Underdale and Grimthorpe. These latter come on again south of Market Weighton. Between Hanging Grimston and Sancton the rocks, which underlie the chalk, are composed of Lower Lias, so that a vast gap appears. The mass of rocks, which constitute the moorland of North-East Yorkshire, consisting of estuarine sandstones, with their intercalated marine limestones, notably the Scarborough, Millepore and Dogger beds, which attain at the Peak a thickness of 600 feet, are wanting, as well as the Upper and Middle Lias. A well, sunk 300 feet, at Huggate, revealed the fact that these beds were absent far within the present western contour of the Wolds. It is, therefore, clearly established that the non-appearance of these rocks is, at all events, not due simply to the overlapping of the chalk.

I am inclined to think, though I speak with hesitation, that the anticlinal above-mentioned is not improbably connected with the ancient anticlinal from the west, noticeable at Harrogate, and that the Liassic beds of North Yorkshire were deposited in a separate area from those of South-East Yorkshire, whilst the lower Oolitic rocks were partly so cut off. The reasons for this opinion I have already stated in some notes on the Hull and Barnsley Railway, contributed at the time of its construction to this Society, and which need not be repeated.

To come to the present railway: commencing at the Driffield end, the line of rails for the first 3½ miles is laid on a slight embankment, crossing the mouth of the valleys from Aldro, Wayrham, Burdale, Sledmere, and Huggate, which here united debouch upon the plain of Holderness. Two cuttings, in the first mile, are in clean water-washed chalk gravel, consisting of small flat pieces of chalk with rounded edges, such as is commonly found in the valley bottoms. From 3½ to 4½ miles there is a cutting in Boulder Clay, showing in the deepest part, 15 feet, the following section:—

	Ft.	In.
Boulder Clay	7	0
Chalk Gravel	2	0
Upper Chalk, without flints	6	0

From this cutting a large boulder of Whin Sill was extracted. There are several others in the immediate vicinity.

In the next cutting, half a mile distant, close to Bainton, also 15 feet deep, six feet of Boulder Clay was exposed, but no chalk gravel. The surface of the underlying chalk was remarkably uneven, having been worn into numerous pockets or pipes, probably by the action of rain charged with carbonic acid.

A capping of Boulder Clay was found as far as 6½ miles, extending to near the village of Middleton. At this place there is an extensive deposit of fine sand, flinty gravel with foreign admixture, and rounded boulders of chalk, which has every appearance of an ancient sea-beach, accumulated in a bight, at an elevation of from 150 feet to 175 feet above sea-level.

A little beyond Middleton the first deep cutting, in Middle Chalk with flints, occurs, reaching at Lair Hill a depth of 32 feet. The prevailing fossil was a large thick-ribbed inoceramus, (*I. Cuvieri*); large rounded balls of flint were also common. Human remains were found at several places in this cutting, as also in the two previous ones, and on the top of Lair Hill the section exposed an unusual depth of surface soil, with several trenches 5 feet deep, in which were found horns and bones of deer.

The chief cutting, 67 feet, is at Enthorpe, distant 10 miles from Driffield. Here a magnificent section of the Middle Chalk is obtained. I counted no less than 39 beds of tabular flints in a depth of about 100 feet, allowing for the dip, most of which were persistent and very marked. The beds of chalk were, as a rule, massive, not slaty, and I identify the zone as that called the "barren zone" of Blake, only it must be quite twice the thickness which he gives. Very few fossils were found. A workman told me that he had hit upon a number of small shells adhering to the under surface of a large flint, but the specimen had not been preserved. An interesting section of a tumulus was exposed on the top of the hill, showing the encircling ditch, 5 feet deep, and 20 yards in diameter, so filled up with earthy matter that its existence would not have been suspected. The mound itself was scarcely visible, having been ploughed down. A whole cluster of tumuli, numbering from 16 to 20, may be seen at this point, which seems to have been a favourite burying place for the early Britons.

Here too the railway cuts through an ancient entrenchment, running north and south for miles each way. A section of the partially filled ditch shows that it must have been seven or eight feet deep, between two ramparts. This entrenchment forms the boundary line of several parishes, e.g., Warter and North Dalton, Lund and Goodmanham ; but it is not always a boundary. Hence I conclude that this, and similar entrenchments, which are frequent on the Wolds, were more ancient than parishes, and were utilized, but not constructed, for marking their boundaries. It is noticeable that every parish between York and Bridlington is bounded by an old road, passing through Wetwang, which follows a line of entrenchments, still preserved on both sides of the monument erected to the late Sir Tatton Sykes.

Another peculiar feature was observed at the Enthorpe cutting, not far from the tumulus first mentioned, but on the opposite (south) side. A large hollow in the chalk rock was exposed, some 25 yards long, with a varying depth of bottom, from 4 feet to 12 feet, consisting of numerous pockets. This was filled in all round the edge of the pockets with black material, clayey soil, and flints partially cemented, having a yellow tinge; streaks of stratified chalk gravel and flints, were visible, in places, running across the face, and the whole was covered with two or more feet of rain-wash.

At the next cutting but one from Enthorpe, distant about ¾ mile, the grey chalk put in its appearance in a slight cutting, 5 feet, on the right hand side. Here a dark-coloured band of marly matter, one foot thick, in the form of an arc of a circle, depressed in the centre to the line of rails, and extending for over 30 yards, was visible, followed by grey chalk, 3 feet, and a second concentric band of grey marl one foot thick. It is probable that this represents the zone of *Belemnitella plena*, which divides the middle from the lower chalk. The same upper bed was represented in the next cutting on the left, only darker in colour, and contorted. The lower marl was absent.

The railway next crosses a slight valley. On the left a well was sunk in the bottom, cutting through Red Chalk some way down; whilst, on the right, 50 yards distant, there is a slight cutting in Red Chalk, evidently the Hunstanton limestone, showing a fault of some 60 or 70 feet. Mr. G. W. Lamplugh tells me that he noticed a yellow band below this red chalk, which may be taken to represent the 6 inch bed of Neocomian to be seen at Acklam Brow, and which I described in my paper on the Red Chalk, communicated in 1878, in a section at Warter Brickyard, as one foot of "orange-coloured clay," between the Red Chalk and Lias.

From this point to Market Weighton the beds consist of Lower Lias; all else is absent.

The next cutting, opposite to Mr. Leighton's house at Goodmanham, presents a curious section, which I give in detail:—

	Ft.	In.
Surface Soil	1	0
Lias Rubble	3	0
Fine Reddish Sand	0	6
Lias Rubble	0	9

	Ft.	In.
Fine White and Pink Sand	0	4
Chalk Wash, with numerous Flints, Fragments of Red Chalk, and Pyrites	1	0

The four lower beds are distinctly stratified, and are due to the action of water, perhaps percolating under an ice-covering; the Lias Rubble on the top may be due to a subsequent slip. The common *Gryphæa incurva* was ubiquitous, and marks the zone as that of *A. Bucklandi.*

In the last cutting, 23 feet, before reaching the road from Goodmanham to Market Weighton, the following section, again allowing for the dip to the N.E., was obtained :—

	Ft.	In.
Limestone and Blue Clay, with *Gryphæa incurva*	6	0
Light-coloured Clays and Limestone : a spring at base	8	0
Blue Clay, thinning west...	3	0
Grey Limestone	1	0
Dark Blue Clay	2	6
Grey Limestone	2	0
Dark Blue Clay, almost black, selenitiferous full of young of *Lima gigantea*	8	0

On the south side these beds were much contorted, probably from slipping, but possibly from glacial pressure, but not on the north side.

Fossils from these beds are in the possession of Mr. Parkinson, of Market Weighton, and may certainly be referred to the *A. angulatus* zone, but whether the lowest bed above-mentioned may be correlated with the upper beds of the *A. planorbis* zone, as I am inclined to think, must be determined by better authorities ; at all events the oyster beds and *Pleuromya* limestones were not reached.

On this elevation, traversed at the base by a road known as Humber Street, leading from Londesborough to Brough, and supposed to be Roman, a quantity of Roman pottery was disinterred from the surface soil, consisting of three kinds, viz., fragments of Samian ware; thin, smooth, light-grey pottery, such as found by Mr. T. Boynton at Ulrome, and coarse black pottery, with particles of chalk in it. Some beads, ornaments of jet, iron spear-heads, and Roman coins were also found. The whole of the above are in the possession of Mr. Parkinson of Market Weighton, who has taken much interest in collecting them.

On the whole the cuttings are decidedly interesting, though they do not add much to our previous geological knowledge.

ON A BOULDER WITH CUP AND RING MARKINGS AT HORSFORTH.

BY WILLIAM CHEETHAM, ESQ.

The Boulder was found a year ago about six inches beneath the surface of the ground, when levelling for Lawn Tennis near Ashfield House, Horsforth, six miles north-west from Leeds, in the valley of the Aire, and about 400 yards north of the Calverley Station.

The Geological Map shows the place to be on the line of the outcrop of Halifax Soft Bed Coal. The Boulder is composed of Millstone Grit, from the rough rock, the uppermost of the series, which here must be 100 to 120 feet below the surface of the ground. Consequently, to some extent, it is a travelled boulder, 5 feet by 4 feet, about 2 feet thick. As to how it got to its position: a suggestion has been made that it might have been brought by glacial action. But there is no need to carry the enquiry far, either as regards distance or time, in connection with the numerous boulders which have been met with in the neighbourhood. During the last forty years I have had great numbers of grit and ganister removed from the land, the latter were easily accounted for; they were from under the Hard Bed Coal, which crops out a little higher up in the valley, and the grits were generally not much rounded, showing that they had travelled, but only a short distance; indeed we have the Rough Rock *in situ* about half a mile westward, and faulted so as to be at a considerably higher elevation. Looking at the valley here as being about 400 yards wide at the lower and 4000 to 5000 yards wide at the upper part, rising some 600 feet, the wonder is not how these blocks of stone got where they have been found, but where the enormous mass of material that once filled the valley has gone to.

From the Geological Map it is seen that we have the Halifax Hard and Soft Beds of Coal cropping out on each side of the valley, of course denuded in the middle, but some portions of the coal were not carried far, as boulders of the Hard Bed, of a good size, were found a few years ago when making a gas-tank on the opposite side of the valley. It was found that although burning without flame they gave out a considerable amount of heat. Probably the reason why they have not been carried far away has been that at the time they were removed a lake filled this portion of the valley, the gravel beds and terraces of the shore lines, at various elevations, being well preserved. Like most of the stones which I have had removed from the land, this boulder is almost covered by markings made by the plough. We have had many a ploughshare broken by them, and probably many have come to grief against this one. The markings can be discerned on a photograph.

Some few months ago, when examining these marks with Mr. Benjamin Holgate, F.G.S., and noting the resemblance which some of them bore to ice scratches, Mr. Holgate noticed the cup and ring markings, and remembering the "Sketch of Pre-Historic Remains of Rombalds Moor," which appeared in the Proceedings of our Society for 1887, by Mr. John Holmes, of Roundhay, we invited Mr. Holmes (who was at the time staying at Ilkley) to come on to Calverley Station and inspect it, and report on the markings. Mr. Holmes met us as requested on the 9th of May, and a short time ago sent his report to me, in which he states "that they are of the same type and kind of figuring as those on Rombalds Moor and at Shipley Glen, and in his judgment, early forms of the said specimens; and that they are correlated to similarly marked stones in England, Scotland, Ireland, Wales, and the Isle of Man. Indeed, further observations have shown that these singularly inscribed stones are found widely spread over the world, from Sweden and Denmark in the north to the South Sea Islands, Fiji, America (North and South); also numerous in Palestine, Moab, Egypt, &c., with variations, but all showing some one definite principle in one common human nature." Mr. Holmes brought over for comparison a large and most interesting collection of sketches and photographs, of similar markings, from almost all the places in the different parts of the world just named. Yet the one shown here was not exactly similar to any of them, nor indeed did any two in his collection appear to be alike notwithstanding their general resemblance. It would appear that if they have expressed definite ideas, the language in which they are inscribed has varied as much as the idioms of spoken languages vary at the present day. There are several casts in the museum of the Philosophical Hall at Leeds taken from the markings on Rombalds Moor, one of them, in the arrangement and dimensions of the figures, is not unlike the one we have brought under your notice. The cups are very distinct and about one inch deep, but the peculiar feature is the absence of rings, which are usual in most markings. It is considered that as regards distinctness the marks on this recently exposed stone compare very favourably with others, one reason being the peculiar and most valuable property of the rough rock of hardening with exposure; another being its uneven surface, which has preserved the fine markings from destruction by the ploughshare, which has evidently obliterated some, as a later and more careful examination has enabled traces to be discovered of several others. The cups are half an inch in depth, and the rings a quarter of an inch; two of them have outlets near three inches in length, and what would appear to give them an astronomical significance is they point to the north. I may say that Mr. Holmes did not attach much importance to these two marks, yet we must suppose they had some connection with the meaning of the inscriptions. Although numerous conjectures have been made no satisfactory solution has been arrived at. Their meaning is yet a mystery.

ON THE DRIFT DEPOSITS OF THE VALE OF MOWBRAY.

BY T. CARTER MITCHELL, ESQ.

The district in which my observations have been made may be roughly described as that part of the Vale of Mowbray which lies between Ripon, Thirsk, and Boroughbridge, being bounded on the west by the river Ure, and on the east by the foot of the Hambleton Hills. Through the centre of this district runs the river Swale. This piece of country seems to be very rich both in quantity and variety of erratic rock fragments. I have not confined my observations to boulders of large size, but extended them to any fragments, however small, which seem interesting as part of the drift. I shall first give a list, though necessarily an imperfect one, from a petrological point of view. I shall then endeavour to refer the boulders to their original stratigraphical position, mentioning the characters of the rocks or of their contained fossils which have guided me in this. Next I shall make some remarks on the local distributions of these erratics, and the direction of the ice or water-currents by which they were brought into the place they occupy.

I shall begin with the Siliceous Rocks as they form a large majority. Fragments of sandstone are present of every size, from great boulders to fine sand, of every degree of hardness, from an almost flinty rock to stone so soft that it perishes after a very short exposure to the weather. In texture they vary from the roughest grits to the finest possible sandstone. In colour there is also great diversity, while the great majority are more or less white or pale yellow, many are red, and more still are red and white, that is to say, consist of white stone mottled with red spots. Some have dark red spots on a pink ground. In some cases the spots which mottle the lighter ground are brown instead of red. A chocolate colour may also be observed, some stones being wholly of a dark chocolate colour. Some of these erratics consist of grit, in which are imbedded numerous rounded pebbles of white quartz. I have found specimens of chert, also of quartzite. In some places there are extensive and thick beds of fine loose red sand ; in other places, a yellow argillacious sand is present, and here and there I have seen white sand turned up. Next in number to the Silicious Rocks are the calcareous masses of Mountain Limestone ; they are very common, as are also pieces of dark limestone from the Yoredale Series. Magnesian Limestone is very plentiful in the gravel of the River Ure. Blue Lias Limestone and Oolitic Limestone are among the rocks of the drift. Crystaline Brown Limestone, full of encrinite stems, and called, I believe, "Yorkshire Marble," is to be found ; and I once met with a large piece of pure white saccharoid marble. Of Argillaceous Rocks we have fragments of blue and green slates, black shale, and large deposits of brick clay ; also a sandy clay, which seems to contain some lime and iron, and in places forms an impermeable structure, which from its hardness seems to be fast turning into stone. It is called "Moor-pan," because it underlies the peaty soil of some of the moors, and prevents the water draining away. Besides the boulders I have enumerated, there are to be found a great many specimens of schistose and metamorphic rocks. In one part pieces of lignite are plentiful, and some specimens of good jet can be found. Four, at least, different kinds of granite are met with, one of which is grey; another is red, not porphyritic, and without mica or hornblende. The commonest kind, found in many places as good-sized boulders, and in every gravel heap in smaller pieces, is the charcteristic Shap Granite. This is light-red, with large porphyritic crystals of pink felspar, also much mica and hornblende. The fourth kind is a brighter red in colour, also full of masses of felspar, but no mica is seen in it, hornblend is present but rather sparingly. Numerous specimens of Basic Igneous Rocks are met with, differing in colour from black to light-grey, and varying much in texture, some close-grained and comparatively smooth specimens of volcanic tufa occur, while others are ragged and course. I ought also to mention pieces of conglomerate and breccia which I have found at times. Septaria or cement stones are very common in some parts. Having recorded examples of the great variety of rocks which have been brought together in the drift, I shall refer some of them to the systems to which they originally belonged. With regard to the numerous schistose and metamorphic stones I am unable to say more than that probably they belong to some of the oldest sedimentary rocks. I think that we may safely consider that the pieces of green slate have been brought from the neighbourhood of Skiddaw, and are Cambrian. The Silurian system has supplied many of the erratics which can be identified by the fossils they contain, as tentaculites, annulatus, pentamerus, etc. I have found the old red sandstone fossil Parka decipiens, the remains of the spawn of a crustacean. There is an immense number of stones from the Carboniferous system in the drift. Sandstones from the upper coal measures are to be found everywhere with casts of stigmaria on them, sigillaria, calamites, and lepidodendron remains are often found. I have one specimen of the latter from a large tree. Great boulders of millstone grit are to be met with. The Yoredale series is plentifully represented, while the mountain limestone erratics are very common. These are fossiliferous, containing encrinites, corals, and large producti. The Permian system is easily detected by pieces of magnesian limestone from the upper beds, and by a red breccia, called in some places brockram, which belongs to the lower part of the system. The lower New Red Sandstone is doubtless present, but this is not easily distinguished from that of the Trias. Permian fossils are scarce, but I have found Productus horridus. With regard to the Trias there is any amount of bunter sandstone, and I have found the typical fossil Ceratites nodosus. The Lias supplies many water rolled stones in which are fossil Gryphæas, etc.; also jet, lignite, and septaria. Pieces of Oolitic limestone are sometimes found, but not often. Thus the stones of the drift in the district which I have defined, are derived from every system from the Jurasic to the Cambrian inclusive, and probably from some earlier formations as well. I am unable to fix the age of the granites and trap rocks present, but the eruption which poured out the Shap granite, which is only to be found *in situ*, at Wastdale Crag and Wastdale Pyke in Westmoreland, occurred after the formation of the green slates, and before the deposition of the old red sandstones. Although all these different rocks are to be met with in a district ten miles square, some are found more plentifully in one part than in another. The Ure gravel on the west side contains more of the magnesian limestone, while the long ridge of rather elevated land which forms the water parting between the Ure and the Swale, and along which the old Roman Watling Street runs, has on both sides of it a tract of land which, though for the most part very fertile, contains great quantities of erratics, interspersed in the soil for a considerable depth. Many of these are very large, and for the most part consist of sandstones, though many other rocks are to be found among them. Most of these are rounded, others are angular. Parallel to this ridge, but a few miles further east, a long range of sand and gravel hills follows the course of the Swale, sometimes on one side of the river sometimes on the other. The gravel in these, the lowest part of the brick clay, is laminated, being interstratified with fine sand. There is no doubt that the chief agent by which the drift, which I have described, was brought into this valley was an enormous sheet of ice which advanced from the north-west, but I also think that there must have been a later and smaller ice-drift which came round the north end of the Hambleton Hills, and kept to the east side of the valley. This glacier would, no doubt, have its origin in the Scandinavian Mountains. But water, as well as ice, has done a great deal towards bringing about the existing state of things. The whole tract of land from the estuary of the Tees through the vales of Mowbray and York to Holderness, is not much elevated, and a very moderate depression would convert it into an arm of the sea. Besides this the thawing of such piled-up accumulations of ice as had gathered through ages of frost, when every atom of vapour was retained as ice in the frozen north, the thawing of these accumulations must have produced torrents of water rushing southward to find again its level in the ocean. By these currents from the north this valley must have been swept again and again, and by them denuded, to what extent the resulting alluvial deposits of Holderness bear witness. The stones of the drift in this part testify in several ways to having been subject to submergence and the action of water; they are, even in the case of very large ones, considerably rounded. Ice markings, though very evident in some cases, are decidedly rare among them ; this, I think, is due to their having been so rubbed and rounded by water action that their surface marks have been obliterated. When these "cobble" stones, as they are called, are used in building, the walls made of them turn wet in damp weather, I believe that this is due to the same cause which makes seaweed turn damp under similar circumstances, that is to say, that they still contain some of the salt which penetrated into them when they were covered by the sea, salt having the power of attracting moisture from the air. I have here very strong evidence of one of these stones having been under the sea ; it is a piece of sandstone which, from its colour, has laid long in the soil. It contains several cells, which have been made in it by some rock-boring shell-fish.

The holes have been nearly globular, but have a short neck through which the tenant communicated with the outside. The cavity is almost exactly like that of a mould for casting a round bullet, the hole by which the hot head enters corresponding to the narrow neck in the stone. I consider that these borings were made by a Pleistocene Saxicava, and the size of the cavities appear to indicate that they were formed by S. artica. This is the more likely, as the few fossils of the drift were for the most part of a northern type.

NOTES ON SOME SINGULAR CAVITIES IN THE MAGNESIAN LIMESTONE.

BY REV. J. STANLEY TUTE, B.A.

PLATE VI.

The cavities or burrows in the Permian Limestone near Wormald Green Station, to which I wish to draw your attention, are of such obscure origin that at one time one is inclined to refer them to the excavations of some early form of Gastrochæna ; at another to an annelid ; then to one of the algæ. Without attempting to say what they really are, I venture only to describe their forms and their position in the limestone, and what I have been able to gather from the observations of others, hoping that the members here present may be able to throw so much light upon the matter that we may come to some probable conclusion as to their origin.

An old quarry, about a quarter of a mile west of Wormald Green, which had been for a long time disused, was opened again a few months ago. In the old and new section about 60 or 70 feet of the middle beds of the Lower Magnesian Limestone have been exposed. Throughout 30 feet of the upper portion of the new part there occur innumerable grooves and cavities of a singular character, agreeing with certain fossil remains which are mentioned by Mr. J. W. Kirkby in a paper read before the Geological Society in 1861,* as occurring in the Lower Permian Limestone of South Yorkshire, at Hampole Stubbs. He says, "the occurrence of another Fossil, of somewhat obscure affinities, though possibly an annelid, may here be noticed. It is the cast of a laterally compressed tube three inches long (neither

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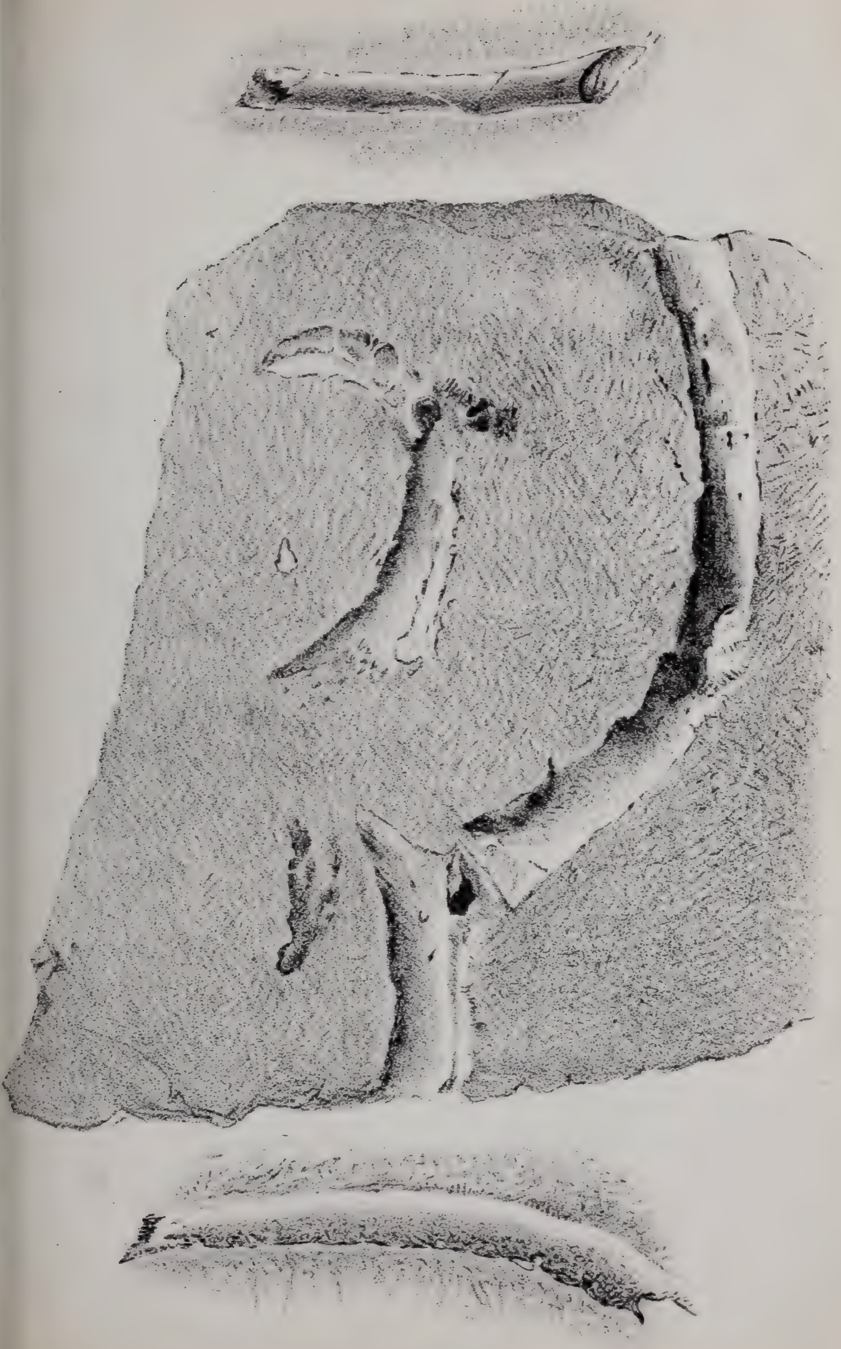
* Quart. Journ. Geological Society 1861, vol. xvii., p. 309.



Tute: Burrows in Magnesian Limestone

end being perfect), $\frac{3}{8}$ of an inch in longest width, $\frac{7}{30}$ in shorter width. It is slightly arcuate longitudinally, and has an oval or rather ovate section transversely, the convex edge being more flatly rounded than the other. Between the cast and the investing matrix there is a slight space, which appears to have been originally occupied by the walls of the tube. A similar fossil has occurred in the Shell and Compact Limestone of Durham, agreeing in most respects with the one described."

The casts in the Wormald Green Limestone agree generally with this description. They are more distinctly arcuate in the more perfect specimens; straighter in the shorter ones; and occasionally appear to spring from an irregularly formed base, which is coloured brown with iron oxide. The internal cast where it exists is formed of small rounded grains of limestone, slightly cemented together, but the tubes are more commonly only partially filled.

Associated with them in the limestone we find Myalina hausmanni, some small gasteropods* and other shells† which from the pliable nature of the deposit are difficult to make out.

The animal which inhabited these cavities may have had habits similar to the common Lob-worm of our present shores, which Nicholson in his Manual of Zoology‡ describes as living "in deep canals, which it hollows out in the sand of the sea-shore, literally eating its way as it proceeds, and passing the sand through the alimentary canal, so as to extract from it any nutriment which it may contain."

I showed the quarry and these organisms to Mr. Richard Howse, the Curator of the Newcastle Museum. He kindly lent me Mr. Kirkby's paper, from which I have taken the foregoing extract. And afterwards he wrote to me saying, "since my return to Newcastle, I have, I think, made out from Dr. Geinitz' 'Dyas' a little about the doubtful organism you kindly showed me in the Wormald Green Quarry. I have also got two specimens from our Middle and Lowest Limestone, which I shall forward for your examination next week, and hope they will satisfy you that the organisms are the same as yours, and most probably Algæ." Mr. Howse also kindly sent me a sketch taken from Geinitz' 'Dyas,' with a description of the fossil, which Geinitz names "Palæophycus insignis;" stem simple, cylindrical, slightly arcuate, with nearly smooth surface, transverse section elliptical; found in the Dolomite Zechstein of Zeimnitz, near Gera,* at a footpath near Ronneburg, and in the Shiefergasse, near Thieschitz. Thus this obscure organism is of very wide occurrence, being found in Durham, Yorkshire, and Germany.

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* Litorina helicina. † Edmondia elongata. Bakewellia antiqua.
‡p. 222.

In still lower beds, near Tanfield, I have found marks and cavities associated with the remains of undoubted algæ, which bear some resemblance to those at Wormald Green, but possess less regular distinctness of outline.

A MONOGRAPH OF YORKSHIRE CARBONIFEROUS AND PERMIAN POLYZOA.

PART II. BY GEORGE ROBERT VINE.†

The study of Palæozoic Polyzoa seems not to have attracted so much attention in this as in other countries, consequently there are fewer monographs to which the student can be referred. Excepting Phillip's Geology of Yorkshire, and Mc.Coy's Palæozoic Fossils of Ireland, nearly all the literature of the subject is to be found in scattered publications, but mostly in local transactions of various Geological Societies. In the first part of this monograph I gave a full list of British papers, but since that was published I have gone over most of the foreign memoirs and papers, all of which will be referred to again when my foreign bibliography is more complete, but I cannot withhold references to two or three American works which are not easily accessible to British students out of London. In the now celebrated volumes of the Geology and Palæontology of New York, vols. I. to VI., a large series of Polyzoa (Bryozoa of authors) from Palæozoic rocks are described and figured. These, to say the least of them, are treated of in a masterly way, by a masterly hand, and the abundance of material and State aid to the describer and lithographer have enabled both author and artist to give very full delineations of a most remarkable group of fossil organisms. Still the nomenclature of many of these fossils is unfamiliar to British students, and this alone will necessitate my giving prefacial introductions to every new group of our Yorkshire fossils. In this, I do not think I shall be accounted tedious by the real student, for the simple reason that an accurate appreciation of a fossil form is a step in the right direction towards the proper classification of the same.

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* Gera is near Jena.

† Part I. Proc. Yorksh. Geol. and Polyt. Soc., vol. xi, Part I. pp. 68-85.

Another very elaborate writer on American Palæozoic Bryozoa (= Polyzoa, in part), is Mr. E. O. Ulrich. I have before me nearly the whole series of Mr. Ulrich's papers, but the long-delayed monographs, vol. VIII. of the Ill. Geological Survey of Illinois and Minnesota, are still unpublished, and cannot be referred to for details. The plates, however, of these two works, by the kindness of Mr. Ulrich, are in my possession, and I cannot withhold my admiration of the way in which the Silurian, Devonian, and Carboniferous Polyzoa of Illinois and the Lower Silurian groups of Minnesota have been treated by the author. One advantage I enjoy in referring to the text of Mr. Ulrich's unpublished report is the reproduction of a part of it, in a separate paper, on "Waverly Bryozoa," which contains a list of the species occurring in Ohio, with descriptions and illustrations of new species.* I have already, when writing on Cystodictyonidæ (part I.), referred to the plates belonging to the Illinois report, but, because they contain figures of several American Carboniferous Polyzoa, closely allied to the British fauna, I shall be obliged to refer to them again and again. The plates lxx. and lxxi.† are wholly occupied with figures of *Rhombopora* and species of *Streblotrypa*, in all twenty-four species. Many of these forms are similar to Yorkshire examples, so much so that some of the figures, only with different names, would serve as illustrations of most of the Yorkshire *Rhombopora*, and *Rhabdomeson* at least, whilst others would justify our placing a larger series before the student of Yorkshire Polyzoa, having distinct specific names, than under present circumstances I am warranted in doing. Out of the twenty-four

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* Bulletin of the Laboratories of Denison University, Granville, O., Dec., 1888.

† Geol. Survey, Illinois, vol. viii.

American types as figured from the Illinois rocks, the most noticeable, as apparent allies of our own, are the following :—

1.	Rhombopora	minor,	Ulrich,	pl. lxx.,	fig. 4.
2.	,,	angustata,	Ul.,	,,	figs. 6, 6*a*.
3.	,,	attenuata,	Ul.,	,,	fig. 7.
4.	,,	exigua,	Ul.,	,,	figs. 10, 10*a*.
5.	,,	incrassata,	Ul.,	,,	fig. 12.
6.	,,	dichotoma,	Ul.,	,,	fig. 13.
7.	Streblotrypa	major,	Ul.,	pl. lxxi.,	fig. 8.
8.	,,	nicklesi,	Ul.,	,,	fig. 9.

Unfortunately [or fortunately ?] in our own Carboniferous rocks, the range of variation of *Rhombopora* and *Rhabdomeson* species is so great, and the links by which the separate examples may be united the one to the other so many, that about four specific names serve to include a large amount of ordinary variation. Hence the vast abundance of British Carboniferous faunal remains of the once widespreading *Rhombopora*, *Rhabdomeson*, and *Fenestella* groups, compel the conscientious British Palæontologist to pause before the creation of new specific names for the rarer offshoots, shall I say ? of the more common species. This restriction reduces our lists of names considerably, and thus, apparently, the British Carboniferous fauna is less interesting to the ordinary student than, judging from names only, the more abundant American Polyzoal fauna. It must not be assumed from the above remarks that I in any way doubt the accuracy of the specific identities of Mr. Ulrich. Honestly, judging from the facial and structural features of his figures, it appears to me that it would be more advantageous to science if we also set limits, in our descriptions, to the ranges of variation in some of our Carboniferous types. In the early days of science certain limitations were acknowledged by Mc.Coy in the Palæozoic Fossils, but since then the twenty-six species of Fenestella, admitted by him, have been reduced to four or five, and I cannot, so far as I am acquainted with the group, revolt against the reduction.

Family HYPHASMOPORIDÆ, Vine.

1885. Family Hyphasmoporidæ (?) Provisional, Proc. Yorks. Geol. and Polyt. Soc., vol. ix.

Zoaria, composed of small, cylindrical, bifurcating stems.

Zoœcia, arranged in linear series, the vestibules of which are separated from each other by reticulated interspaces.

In 1885 I proposed the above family name for the inclusion of two peculiar species of Carboniferous Polyzoa, *Hyphasmopora Baskii*, Eth. Jun. and *Streblotrypa nicklisii*, Ul. M.S., var. *minuta*, Vine. The first of these species was described by R. Etheredge, jun., in 1875,† and the variety of *Streblotrypa* was new to British Carboniferous rocks. Since my papers were written Mr. E. O. Ulrich has published details of several American species of Polyzoa allied to *Hyphasmopora*, but which are placed under a new family name, STREBLOTRYPIDÆ. In his paper on the "Waverly Bryozoa,"‡ Mr. Ulrich says (op. cit. p. 84) "The genus *Streblotrypa* was proposed in manuscript by me several years ago, and specimens of the type species, *S. nicklisii*, Ul. (Ill. Geol. Survey, vol. VIII.) were sent to Students of Palæozoic Bryozoa. The name was adopted for a supposed variety of the type species by Mr. G. R. Vine in 1886.‖ During November or December, 1887, there appeared Vol. VI. of the Palæontology of New York. In looking over this fine work, I find that Prof. Hall has placed at least one species under his new genus, *Acanthoclema*, that ought rather to be regarded as a form of *Streblotrypa*. The species referred to is the *Ceriopora hamiltonensis* of Nicholson."

In referring to the description of this species by the author, I find that Nicholson places it as follows:§ *Ceriopora? hamiltonensis*, Nich.," and remarks that "this beautiful little fossil occurs in great abundance in some of the beds of the Hamilton formation. It is allied to *Ceriopora punctata*, Goldf.¶ and to *Millepora interporosa*, Phill.** especially to the former; but it is distinguished from both by perfectly good and easily recognised characters. I am at present unable to decide as to its true generic affinities, and have simply referred it provisionally to *Ceriopora* on account of its close relationship to *C. punctata*, Goldf., which likewise occurs in the Devonian rocks."

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* Part I. Proc. Yorks. Geol. and Polytec. Soc. vol. xi., pl. 1, pp. 68-85.
† Ann. Mag. Nat. Hist., Ser. 4, vol. xv.
‡ Bulletin of the Laboratories of Denison University, Granville, Dec., 1888.
‖ Notes on Yoredale Polyzoa, Proc. York. Geol. Soc., &c., vol. ix. (op. cit).
§ New Devonian Polyzoa Geol, Mag., 1874, p. 24.
¶ Petrifac, pl. lxiv., f. 13.
** Geol. Yorks., vol. ii. pl. i, f. 36-39.

In Mr. Ulrich's "Waverly Bryozoa," already referred to, the author describes eight species, one doubtful, of *Streblotrypa*, only one of which, *S. major*, Ul., can claim relationship with British forms of the Hyphasmoporidæ. It is well, therefore, for the student of Palæozoic Polyzoa to bear in mind that the species cited by Nicholson in the above quotation are now very widely separated both by himself and Ulrich, consequently the affinity, or apparent affinities, as suggested are somewhat doubtful. Probably the *Millipora interporosa*, Phill., is a coral (Hydrozoon) rather than a Polyzoon.

Genus Hyphasmopora, Eth. Jun.

1875. Ann. Mag. Nat. Hist. Ser. 4, vol. xv., pp. 43-45.

Zoarium, composed of small cylindrical stems, often bifurcating. *Zoœcia* arranged in linear longitudinal series, the vestibules of which are separated from each other by "cancellated" or "reticulated" interspaces. *Vestibules,* large, oval, or pyriform, slanting inwards, at the base of which are the true circular zoœcial apertures. The vestibular openings are found on three sides of the stem only, and the reverse, if such a term is allowable for cylindrical stems, are wholly reticulated. *Gonocysts,* inflated sacs., having an opening on the top, or upper side, and reticulated on the exposed surface of the sac, like the reverse of the stem.

Hyphasmopora Buskii, Eth. Jun. (pl. vii., fig. 4.)

1875. Ann. Mag. Natural Hist., Ser. 4, vol. xv., pp. 43-45, pl. iv., figs. 1-4.
1882. Hyphasmopora Buskii, Vine, Proc. Yorks. Geol. Soc., vol. vii., p. 337, pl. xvi., fig. 6.
1883. ,, ,, Vine, Proc. Yorks. Geol. Soc., vol. ix., p. 26.
1884. ,, ,, Vine, Yorks. "Naturalist," Oct., p. 64.
1885. ,, ,, Vine, ,, ,, Sept., p. 316.

This species is found in the Scotch, Northumberland, Lancashire and Yorkshire shales, but it is by no means so abundant in the English Carboniferous, as in the Scotch shales. The chief interest in the present reference to the species is on account of the ovicells.

The gonocysts of this species are described and figured for the first time. They consist of small inflated sacs, which occupy various positions on the stem, and not always in a line with the growing part of the same. In the course of my investigations I have gathered together a rather large assortment of these "ovicells," but in every case their characters are similar. Two of the best of these are figured (pl. vii., fig. 1) as placed on the side of the stem. The sac is oval, and the lateral vestibule on the right hand side is pushed out of position, while the "network" of the stem is, on the base especially, interwoven with the sac. The orifice of the gonocyst of this example is very perfect, and is bordered by a slight rim, and just below the orifice is a second "opening," much smaller in size, the function or purpose of which I cannot make out, but otherwise the "orifice" proper is very characteristic, and is on a par with the "ovicells" of Cyclostomatous species already figured by authors. The second example, (pl. vii., fig. 2), is similar in every respect, excepting the slightly zig-zag orifice which may or may not represent an abrasion, but the "opening" below is more perfect in this example. The "ovicell" is, as will been seen, apparently reversed. Other gonocysts of this species are placed in the angle formed by the branches. These are similar to those described above, and the "network" which envelop the sac is like that of the reverse rather than of the inter-vestibular spaces, but no reliance can be placed upon this variation of character for specific or descriptive purposes. I have, however, sectioned an example which has been formed in the angle of the branches (pl. vii., fig. 3), and the peculiar mode of attachment of the "network" to the stem, and also the orifice are very well shown in the figure. The examples described are characteristic and typical "ovicells" of *Hyphasmopora* generally.

I do not think that there can be any question respecting the function of these peculiar sacs, but in all honesty, though I may be the first to figure and describe them, I believe that both Mr. Etheredge, jun., and Mr. John Young, of Glasgow, have noticed the "growths" on some of these fragments of *Hyphasmopora*, though they may not have noticed similar "growths" on other Carboniferous species.

The infrequency of ovicells on fragments of Carboniferous Polyzoa need not occasion much surprise, when it is stated, by Mr. Waters, that out of the large number of *Idmonea*, about 130 species and varieties which have been described, only seven species have been noticed as bearing ovicells; and out of a large list of *Hornera*, seventy-four, I believe, the ovicell is only known in about nine species.*

It will be noticed in both fragments of *Hyphasmopora* figured that there are two openings in the ovicells, one on the apex and the other on the side; but in figure 2 the inferior opening is much more distinct than in figure 1. Mr. Waters, in dealing with the ovicells of recent Cyclostomata, has a very pertinent remark on these openings, and I cannot do better than quote it, more especially as, in the passage I have underlined, the remarks of Mr. Kirkpatrick will apply to Carboniferous as well as to recent species.

"The position and nature of the opening of the ovicell is most important, often in fact, more so than the shape of the ovicell. The opening is, however, formed after the ovicell is complete, so that frequently this important character cannot be made out, and in my specimen (*Hornera fissurata*, Busk) I could not find any opening, but one of the lateral zoœcial tubes is much longer than usual, and looked as though this change was connected with the functions of the ovicell. I therefore wrote to Mr. Kirkpatrick, of the British Museum, explaining what I had seen in my specimens, and asked him if he would look at those in the Museum.† He kindly did so at once, and wrote that he had examined ten ovicells, and found in each instance *that the last one or two Zoœcia of a series in proximity to an ovicell are not only enlarged, but considerably altered in direction.* In eight instances the tube curved forwards and upwards so as to open on the anterior surface. In two, the tubes opened laterally. In every case the wide tube is to some extent connate to a Zoœcial series; but in some cases the former curves away from the latter in such a way as to make the wide tube appear to be part of the ovicell, and not a metamorphosed Zoœcium."‡

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* Ovicells of Cyclos. Bryozoa. Linn. Soc Jour. Zool., vol. xx., p. 276.

† Mounted and presented to the Museum by Miss Busk, from her father's "Challenger" Collection of *Idmonea* (Hornera) *fissurata*, Busk.

‡ Op. cit. pp. 276-277.

Of late years very great attention has been given to the proper classification of the ovicells of the Cyclostomata especially, and it behoves every worker on the sub-order to help to throw all the light possible on this most interesting, but at times very difficult subject. Classifications serve their day, but structural elements and structural peculiarities in any form are valuable aids in zoological investigation, but the proper definition of these elemental structures may help to serve as adjuncts for a higher appreciation of varietal changes in a species, both in time and space, than we now possess. Ovicells in a species tell a far more reliable tale than the robust or diminutive cell is capable of telling, hence their importance in the definition of a group.

Genus STREBLOTRYPA, Ulrich.

III. Geological Survey, vol. viii. (Aug., 1889, still unpub.)

Streblotrypa nicklisi, Ul. (MS. 1883 ?) pl. vii., figs. 6 and 7.

1883. *S. nicklisi*, Vine, Proc. Yorksh. Geol. Soc., vol. viii., p. 107, pl. xxi., figs. 4 and 5.

1887. *S. nicklisi*, Ulrich, III. Geol. Survey, Illinois, vol. viii., figs. 9 *a* to *c*.

Unfortunately I cannot redescribe my Yorkshire example of this beautiful species, as the fragment which was described and figured in the Proceedings cited above, is evidently lost. For the purpose of this monograph I have re-examined all my Yorkshire Polyzoa, and I was sorry when I came to this species for redescription and found that my specimen was gone, though the place on the slide showed the vacant space where it was once attached. I have to rely in consequence on my previous work. "The small fragment was about 1¼ lines in length, and about ¼ line in width. In the whole length of the fragment, taking a row of cells, I find there are about 7 cells, or being more accurate, 6½ cells [to the 1¼ lines]. A fragment of the American form of the same dimensions, for some specimens are more bulky than ours, affords the same results."*

In the note already cited from Mr. Ulrich's "Waverley Bryozoa," the author quotes from my Yoredale Polyzoa paper,† and he seems to have overlooked the Yorkshire one. Even with Mr. Ulrich's beautiful figure before me (pl. lxxi., and figs. 9 to 9c), I cannot help quoting from my paper again. "One of the differences between certain of the American and Yorkshire forms may be noted. In some specimens of *S. Nicklisi*, Ul., from Kaskaskia, there appears to be delicate ridges developed in parallel or wavy lines, which seem to separate the cells into parallel or waving rows, in other specimens, especially in the younger portions of the branch, that is in the apices, there are no ridges, and in this respect both the American and British forms agree."* In the cancellated interspaces between cell and cell in the figured specimen of *S. Nicklisi* (pl. lxxi., fig. 9a) there are two and three rows of punctures, varying in number, as a whole, from 8 to 12 punctures below the cell mouth. In the Yorkshire example as figured, the punctures varied from five to seven or eight, while the cancellation below the orifice in *Streblotrypa minuta*, Vine, (= *S. Nicklisi*, Ul., var. *minuta*, Vine), though very faintly displayed in the fossils, vary from five to seven. Fortunately, however, one of my examples of *S. minuta* (pl. vii., fig. 8), from Gleaston Castle (Yoredale Rocks, Lancashire), bear just below the bifurcatum of the branch a small ovicell which I seem to have previously overlooked, and this appears to me to justify my inclusion of the genus *Streblotrypa* in the family *Hyphasmoporidæ*, rather than any other. The ovicell though not so large or so prominent on the surface of the Zoarium as in examples of *Hyphasmopora*, is still similar in character. The sac is rather more rounded, is situated just below the angle formed by a bifurcating branch, and the surface is faintly cancellated similar to the cancellation of the interspaces between cell and cell in the branch; and the opening of the ovicell is on the right hand side. During a visit, some years ago now, that I had with Mr. John Young, of Glasgow, he showed me several examples of a Carboniferous species of Polyzoa which I regard as *Streblotrypa*, and in all probability many other examples would be found in our British rocks if more persistent research was made.

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* Vine, Proc. Yorks. Geol. Soc. 1884, vol. lviii., p. 108.

† Vine, Proc. Yorks. and Polyt. Soc., vol. ix., pp. 1-29. Since Mr. Ulrich has published details of his species, *S. Nicklisi*, Ul., I think it wise to alter the British reference thus: *Streblotrypa minuta*, Vine (= *S. Nicklisi*, Ul., var. *minuta*, Vine) The figures in plate x., figs. 7 to 9, are not good, and at some future time will be redrawn. Of this species I have about seven examples.

There is one very remarkable species, *Streblotrypa Hertzeri*, Ul., in Mr. Ulrich's Waverley Bryozoa (p. 85, pl. xiv. fig. 8) which closely resembles some of the examples of our British *Archæopora nexiles*, De Kon.[*] Indeed I have stem-like examples from Brankamhall before me that would answer very well for the definition of *S. Hertzeri*, in Mr. Ulrich's text, but the general run of the examples of *A. nexiles* in the Yorkshire shales are either encrusting on the flat, or enveloping fragments of spines or other foreign bodies. At present, however, I am not in a position to say where this species will be ultimately placed in our Zoological arrangements.

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* Proc. Yorks. Geol. Polyt. Soc., vol. viii., p. 107.

Family RHABDOMESONTIDÆ, Vine.

1883. Rhabdomesontidæ, Vine, 4th Brit. Assoc. Rep. Foss. Polyzoa, p. 45 of Report.
1883-4. ,, ,, Proc. Yorks. Geol. Soc., vol. viii., p. 105.
1884-5. ,, ,, Yorksh. "Naturalist," p. 66, 1884, p. 317, 1885.
1885. ,, ,, Proc. Yorks. Geol. Soc., vol. ix., p. 21.
1887. ,, ,, Polyz. Gayton Boring Jour. Northampton Soc. Nat. History.
1884. Rhabdomesontidæ, Vine, (Ulrich), Jour. Cincin. Soc. Nat. Hist., vol. vii., p. 24.

Zoarium rod-like, branching. *Zoœcia* opening on all sides of the branch, tubular, attached by their proximal extremities to a central rod. Orifice of cells obscured by vestibule; wall of vestibule externally ornamented by spines or not.

Section A. Zoœcia attached to a central rod.

Section B. Zoœcia radiating in all directions from an imaginary axis.

In my fourth British Association Report on Fossil Polyzoa, I suggested the family name Rhabdomesontidæ for the inclusion of two remarkable fossils, which were known to Palæontologists from Phillips' descriptions, under the names of *Millepora* and *Ceriopora*. These species, with better examples than Phillips possessed, were re-worked by the Messrs. Young, of Glasgow, who discovered that one species at least, *Millepora gracilis*, Phill., was undoubtedly built up round a central rod. On this account they re-christened the species *Rhabdomeson*.

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[*] Vine: 1st Brit. Assoc. Report, pp. 8-9 of Report. This is the only place where the species, which is very abundant in the Scotch shales, has been described.

On the publication of my family name, which originally appeared without the sub-section B., Mr. E. O. Ulrich readily adopted the name, but in his definition of the family he included *Rhombopora*, Meek, and he further suggests that probably *Anisotrypa*, Ul., may ultimately be placed in the family. Following this suggestion, and wishing, for the sake of working Palæontologists, to keep myself in accord with American workers, I subsequently adopted the sub-section B in my Yoredale Polyzoa, and in the Polyzoa of the Gayton Boring.* As both sections of the family are largely represented in the Yorkshire as in other British Carboniferous rocks, it may be as well to give rather full notes on the Yorkshire species especially.

Genus RHABDOMESON, Young and Young.

1874. Rhabdomeson, Y. and Y., Ann. Mag. Nat. Hist. Ser. 4, vol. xiii., p. 327.
1875. ,, ,, Ibid, vol. xv., p. 334.
1884-5. ,, (Section A), Vine, Proc. Yorks. Geol. Soc., vol. ix., p. 23.

SECTION A.

Zoarium slender, rod like. Axis a thin calcareous tube to which the Zoœcia are attached, and from which they radiate in all directions.

I. RHABDOMESON GRACILE, Young and Young.

1841.? Millepora gracilis, Phill., Pal. Foss., Cornwall, Devon, etc.
1854.? Ceriopora gracilis, Morris, Catalogue Brit. Fossils; Millepora gracilis? McCoy, Carb. Foss., Ireland, p. 195.
1874. Rhabdomeson gracile, Young and Y., Ann. Mag. Nat. Hist., vol. xiii., pl. xv., figs. 1-6.
1875. ,, ,, John Young, Trans. Eding. Geol. Soc., pp. 400-402.
1880-1. ,, ,, Vine, 1st Brit. Assoc. Rep. Foss. Poly.
1881-2. ,, ,, Vine, Proc. Yorks. Geol. and Polyt. Soc., vol. vii.

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* See 1885 and 1887 papers in Bibliography at the head of this section.

1883-4. Rhabdomeson gracilis (error), Vine, Ibid, p. 174.
1884-5. ,, gracile, Vine, Naturalist, p. 66, and 1885, p. 317.
1885. ,, ,, Vine, Trans. Yorks. Geol. Soc., vol. ix., p. 23, pl. x., fig. ii.

Zoarium rod-like, slender, cylindrical and branching. *Branches* coming off at right angles to the stem, and never less than an inch apart. *Stem* consisting of a hollow axis formed by a thin calcareous tube, and of a series of cells ranged round the axis. *Zoœcial* apertures (vestibule) oval, surrounded by tuberculated ridges, which bear two blunt spines, one on the upper and the other on the lower angles of each aperture. *Zoœcia* conical, consisting of two parts, the vestibule and the cell proper.

Range in British Rocks: (Devonian, Pilton beds ? Phillips). Carboniferous :—Yorkshire : Hurst and Richmond ; Derbyshire : Castleton ; Wales : Llangolen and Holken, rather rare ; North Lancashire : Holker Park, Gleaston Castle, and Little Urswich ; Northumberland : fairly abundant. Scotch Carboniferous Shales, Upper and Lower, very abundant.

This very widely distributed and abundant species has been, so far as the structure is concerned, very fairly described by the Messrs. Young, and by myself in the various papers already referred to. Up to the present time, although some thousands of examples have passed through my hands, I have never met with a single specimen bearing an ovicell, or any other indication of a reproductive cell. This is the more remarkable as ovicells have been found on examples of *R. rhombiferum*.

In my paper on the Polyzoa of the Gayton boring, Northampton, I have expressed a doubt as to whether the *Millepora gracilis* of the Pilton beds really belong to the Rhabdomeson group. To try and settle this question I wrote to Mr. Hall, whose paper on the Pilton beds was quoted by me, in the hope that I might get from him examples of the true Pilton form. This I failed in, but he referred me for examination to a complete series of the fossils which he had sent in to the British Museum. Recently I have, through the kindness of Mr. E. B. Newton, of the Brit. Mus., Cromwell Road, Kensington, examined the Townsend Hall collection of the Pilton fossils, but I could not find any trace of the fossils I was in search of. Indeed, judging from Mr. Hall's paper, and lists of fossils, I now doubt whether he ever saw the *Millepora gracilis*, Phill. Not to be baffled, however, I wrote to Mr. Newton again, asking him if he could tell me where Phillips' types were, but he writes me (Sept. 23, 1889), "I am unable to say where Phillips' type of *Millepora* (Ceriopora) *gracilis* may be, but I have made a rough tracing of the figure, and copied word for word the description given." So far good, but not wholly satisfactory.

Genus *Millepora*. *Millepora gracilis*. *Character*: slender, cylindrical; surface covered by oval or sub-rhomboidal cells, the terminations of tubes passing obliquely from the axis. Intercellular spaces granular (or porous?); no branched specimens have been seen. It is closely allied to *Millepora rhombifera*, Phillips' Geology of Yorkshire, vol. ii., pl. i., f. 35.

Locality in North Devon: Croyde, Brushford, Pilton. Phill. Palæozoic Fossils, p.p. 20, 21, pl. xi., figs. 31*a*, 31*b*.

The brief description of *Millepora rhombifera* is as follows:—"Branches cylindrical, with acute rhomboidal cells in quincunx." Geology of Yorkshire, vol. ii., pl. i., f. 35, p. 199.

If any of my readers possess an example of the Pilton *Millepora* I should be glad to examine it.

RHABDOMESON RHOMBIFERUM (Phillips' sp.? pl. vii., fig. 5).

1836. Millepora rhombifera, Phill. Geol. Yorkshire. p. 199.
1854. Ceriopora ,, Morris' Catal. Brit. Fossils.
1875. Rhabdomeson rhombiferum, Young and Young, Ann. Mag. Nat. Hist., Ser. 4, vol. xxi., pp. 333-336, pl. ix. *See* Nomenclature and references as under *R. gracile*.

Zoarium stem-like, slender, cylindrical, free. *Branches* of nearly equal diameter, given off at wide intervals and at right angles to the stem. *Zoœcia* in quincunx all round the stem. *Vestibules* rhomboidal or hexagonal in outline and bounded by tuberculated ridges; area of vestibules larger on one face than on the other, and slanting inwards towards a narrow opening, the true orifice of the Zoœcia. *Tubercles*, large at the angles of junction, average number of tubercles round each area about sixteen. Central axis slender and slightly flexuous. *Gonocysts* oval, compressed or elongated.

The distribution of this species, so far as I am aware, is rather more restricted than the former, *R. gracile,* as I have not met with examples either in Wales or Derbyshire, but I should not like to say that it is absent from these places. Otherwise I have nearly always found *R. rhombiferum* wherever *R. gracile* was fairly abundant.

In looking over the figures of Phillips, in Geology of Yorkshire, and ticking off his very brief description, I think it no detriment to the author to say that as Phillips speaks of *M. rhombifera* only, in all probability that which passes now as *R. gracile* in the Yorkshire rocks, was non-existent at the time he wrote. The distinction between the two species being unknown, or at least unrecorded, I believe that the name *Millepora rhombifera* covered the now, two distinct species. We owe to the letter of Phillips* to the Messrs. Young, of Glasgow, the statement, "Your examples are better than mine were, but I have no doubt of the reference. The difference of opposite faces of *C.* or *Rh. rhombifera* is very interesting," a possible confirmation of this view. The ovicells of this species are most peculiar. One of the best I have figured (pl. vii., f. 5), and it will be seen to be entirely unlike any of the ovicells described in the first part, or on the present memoir. In itself it is a perfect study. The form is a sac (elongated oval ?) tapering, or rather thinning out towards the apex, in which is a small orifice, but there is no secondary opening in the sac. Surface of the ovicell much roughed by delicate wart-like prominences, which give to the surface a peculiar granular appearance. This, however, is in keeping with the granulation which is seen occasionally on the surface of the vestibular area just below the spines which ornament the walls of the same. On the side of the ovicell the Zoœcial apertures are slightly altered in appearance, but they are not, so far as I can see, pushed out of position much. As ovicells of *Rhabdomeson rhombiferum* are very rare, I hope, now that I have directed attention to them, workers will look out for ovicells of *R. gracile* as well.

Section B. Zoœcia radiating in all directions round an imaginary axis.

Genus Rhombopora, Meek.

1871. F. B. Meek, Palæontology, Eastern Nebraska.

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* Ann. Mag. Nat. Hist., 1875, p. 334.

1884. E. O. Ulrich, Jour. Cincin. Soc. Nat. Hist., vol. vii., p. 26.

1883-4. G. R. Vine (Additional Notes, p. 105), Proc. Yorksh. Geol. Soc., vol. viii.

Zoarium ramose, branches slender. *Zoœcia* tubular, radiating in all directions from an imaginary axis. *Zoœcial* apertures circular or oval, placed at the bottom of more or less obviously impressed, sloping rhomboidal or hexagonal vestibules. Ridges separating vestibules spiniferous, spines hollow, and of two kinds, large and small, the latter most numerous, and surrounding the vestibules, while larger spines are occasionally developed only at the upper extremity of the cell.

Type of Meek *R. lepidodendroidea*, Up. Coal Measures, Nebraska.

As species of this genus are rather abundant in American rocks, I have adopted, to a large extent, the definitions given by Mr. Ulrich in the Journal cited above, 1884.

I have already quoted the names of several species of *Rhombopora* as apparent allies of Yorkshire forms. The following is a full and unprejudiced description of the Yorkshire species that I have heretofore detected.

I. RHOMBOPORA LEPIDODENDROIDEA ? Meek.

1871. R. lepidodendroidea, Meek. Palæon. Eastern Nebraska, p. 141., pl. vii., fig 2, &c.

1884. R. lepidodendroidea, Ulrich. Jour. Cincin. Soc. Nat. Hist., vol. vii., pp. 26-27, pl. i., fig. 1.

1884. R. lepidodendroidea ? Vine. (Additional Notes) Proc. Yorks. Geol. Soc., vol. viii., p. 106.

The above is the type species of Meek, and when comparing American examples with our own, I think I may place its existence here on record. The Yorkshire examples are much less slender than the American, but there is a close similarity in the facial features: but as my material is limited I still retain the doubt.

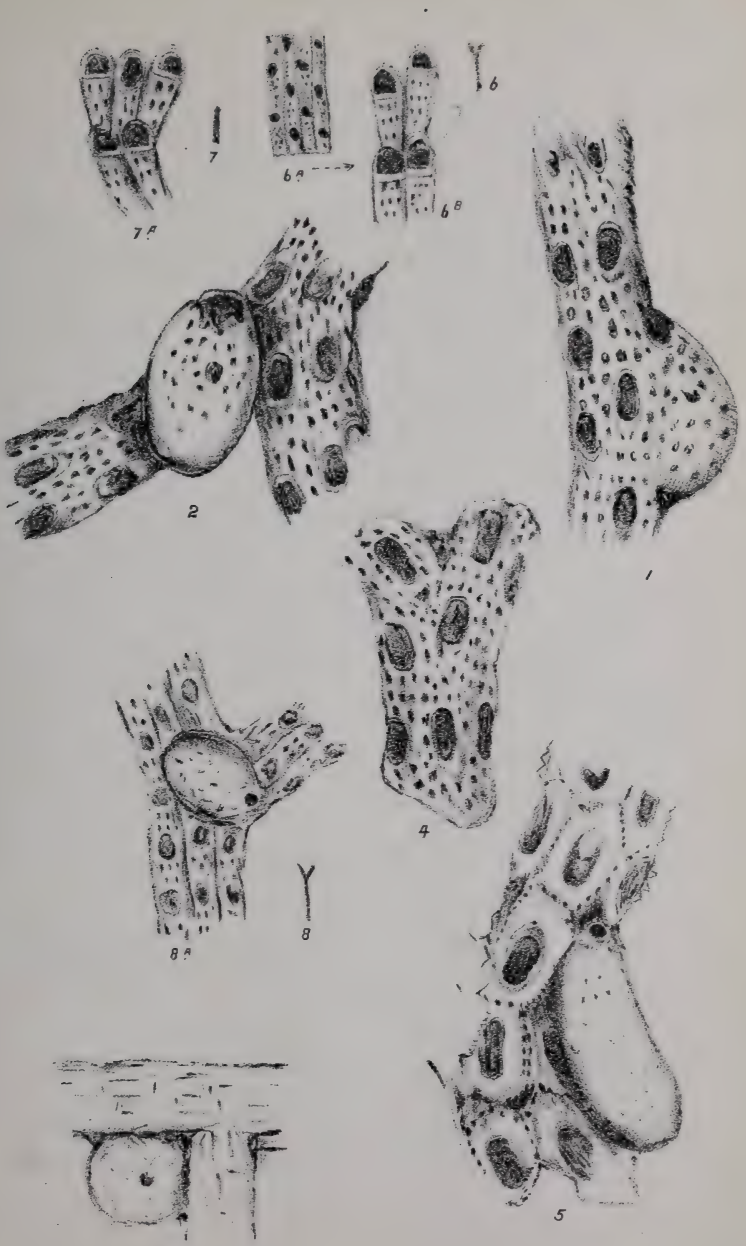
Locality: Hurst, North Yorkshire.

2. RHOMBOPORA SIMILIS, Phill., sp.

1841. Ceriopora similis, Phill. Palæoz. Fossils of Devon, &c.

1881. „ „ Vine, Proc. Yorks. Geol Soc., vol. vii., p. 338.

Proc. Yorksh. Geol. & Polyt. Soc., Vol. XI., Pl. VII.



VINE: CARBONIFEROUS POLYZOA.

1885-6. Rhombopora similis? Vine, Proc. Yorks Geol. Soc., vol. ix., p. 24.

Zoarium rod like, or branching. *Zoœcia* circular or hexagonal. *Vestibular* area well defined, sloping inward, at the bottom of which is the Zoœcial aperture. The walls surrounding the vestibular area are ornamented with a varying number of blunt spines, which in sections are seen to be hollow.

Locality: Hurst, Yorkshire; North Lancashire; the species is found in some of the Scotch horizons also, but it seems to have had a limited range in British rocks at least.

In a species of *Rhombopora* described by Mr. Ulrich as *R. elegantula*, Ul.,* similar facial features to the above are noticeable, but the branching of the American form is different.

3. RHOMBOPORA PERSIMILIS, Ulrich.

1884. R. persimilis, Ulrich, Jour. Cincin. Soc. Nat. Hist. p. 30.
1884. R. persimilis, Vine, Proc. Yorksh. Geol. Soc., vol. viii., p. 106.
1885-6. R. persimilis, Vine, Ibid, vol. ix., p. 24.
1887. R. persimilis (var. B.) Vine, Jour. Northampton Soc. Nat. History, p. 11.

The above has been described rather fully in the above papers, and the Yorkshire examples especially in the 1884 paper quoted from this journal.

Localities: British forms: Hurst, Yorkshire; North Lancashire; Gayton Boring, Northampton. *American forms:* Kaskaskia group, Lower Carb. Rocks, Chester, Ill.; Tateville, Kg. (Ulrich.)

DESCRIPTION OF FIGURES. PLATE VII.

1. Hyphasmopora, Buskii, Eth. Jun., with lateral "ovicell," × 30.
2. ,, ,, ,, with "ovicell" in branch, × 30.
3. ,, ,, ,, Section of "ovicell" in the angle of branch; transparent. All from Carb. Shale, Brankemhall, Scotland. My own cabinet.
4. Hyphasmopora Buskii, Eth. J. Fragment, Hurst, Yorkshire.
5. Rhabdomeson rhombiferum (Phill. sp.), with "ovicell," × 30. Brankemhall, Scotland.

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* **Journ. Cincin. Soc. Nat. Hist., April, 1884, p. 33.**

6. Streblotrypa nicklisi, Ulrich, (from typical example in my own cabinet, Kaskaskia, U. S. Am.) 6, natural size; 6*a*, portion of branch magnified with mid-ribs; 6*b*, drawn from the younger or growing portions of stem, no ribs.
7. Streblotrypa nicklisi (MS., Ul.). Yorkshire form (example lost). 7*c*, natural size 7*a*, from branch without mid-ribs.
8. Streblotrypa minuta, Vine, Lancashire. Example with "ovicell."

Figs. 1 to 5 drawn in outline with Camera lucida, and low power (1¾ inch object glass), details put in after.

NOTES ON UNDERGROUND WATER-SUPPLY AND RIVER FLOODS.

BY CHAS. E. DE RANCE, F.G.S., F.R.G.S., A.I.C.E.,

Secretary of the Underground Water Committee of the British Association.

Rainfall:—The first systematic observation of rainfall was much more than two centuries ago, on the Yorkshire border, by a Lancashire Squire, one of the Townleys of Townley, near Burnley. A century later, in 1766, Dr. Heberden, F.R.S., placed a rain guage on the top of the square tower of Westminster Abbey, and two others in the neighbourhood, but it was not until 1859 that any one was found bold enough to grapple with the subject as a whole. Mr. G. J. Symons, F.R.S,, in that year commenced to collect copies of records of the fall of rain over the United Kingdom, and early in 1861 wrote to all observers known to him, asking them to send him records for the year 1860. Of these 168 replied, and their publication gave such a stimulus to observers that in 1863 we find him writing to the *Times* that he had nearly 700 stations, and the year after we find him stating that hitherto the tables had been the product of his leisure hours, but that they are so no longer; that the development of the enquiry had been so rapid, and its bearing on manufacturing, engineering, agricultural and sanitary questions so important, that he had resigned all other engagements, sacrificing pecuniary prospects rather "than abandon an investigation the ramification and importance of which we cannot see." In the current volume of British Rainfall, Mr. Sỳmons calls attention that the fourth decade of his rainfall work commences with the new year; the separate observers, irrespective of corporate bodies, amount to no less than 2,200; the number of stations have been raised to 2,700; the modest four-page pamphlet of 1861 has been developed into a volume of 200 closely-printed pages, while its production necessitated the annual receipt and issue of more than 30,000 documents; the cost of the publication of the results; the salaries of observers in districts where volunteers cannot be obtained; the payment of two regular clerks and for extra assistance at times of pressure, for printing and posting is entirely defrayed by annual subscriptions of the general public; and of about 300 of the observing staff.

When the importance of these observations and their bearing on the well-being of the nation is realized, it appears an anomalous condition of affairs that no assistance should be provided by the nation for a matter of such grave national importance; for though there is no reason to suppose there will, in the future, be a lack of observers who will give their time and contribute to the expense of tabulating their observations, there are two serious drawbacks, *first*, that the whole organization is kept together by a volunteer chief, and is dependent for its continuity on his industry, self-abnegation, personal influence, and good health; *second*, that funds are not available to send out trained inspectors of rain-gauges, or to compute and print the local averages of rainfall, for which ample material is now collected.

Looking to the fact that rain is the source of all fresh water obtainable, whether flowing at the surface, issuing as springs, stored in reservoirs, reached in borings, present in the bodies of men and animals, whether consumed by them, absorbed by agricultural crops, utilized in manufacturing processes, the purposes of inland navigation, the preservation of fisheries, the production of steam, or electric energy. The annual volume of Mr. Symons may be regarded as a record of the Nation's "Water Capital" for the year, of which a certain proportion has to be written off as "loss," evaporation into the atmosphere of perhaps a third, before the record of it is in print, and an absorption of probably another third in areas containing porous rocks, which quantity is partly recovered by natural springs, and in districts of artesian wells, the loss from this cause is inappreciable. From these considerations it would appear that at least one-third of the annual rainfall was available for running waters, to be used in the maintenance of life, and utilized for the purposes of trade, but this is not the case, a large amount has to be "written off," for "depreciation" caused by *floods*. It is often stated that England and Wales offers an epitome of the Geology of Europe, it is equally true that the large County of Yorkshire offers an epitome of the Geology of South Britain, with one important exception as regards its hydrogeological condition, the absence of any extensive area, of wholly impermeable strata, like the Silurian and Cambrian rocks of Wales and the English Lake District, where the whole of the rainfall is either run off in floods or caught and arrested in lakes, some of which are rock-basins, others produced by old glacier moraine dams, others by dams of masonry, like the Vyrnwy Lake of the Liverpool Corporation Waterworks. In these districts the water is either caught or lost. The dry weather flow of the streams averaging only one-fourth to three-fourths of a cubic foot per second per 1000 acres drained, due to water arrested by peat-mosses in the high uplands, which slowly give off their moisture like a sponge, while the volume of these streams in periods of floods is often 500 cubic feet per second per 1000 acres drained.

The whole of the Yorkshire Rocks, of all geological ages, form a series of alternating porous permeable material, alternating with impermeable shales and clays, which, succeeding each other in regular order, dip with the slope of the ground from the western water-shed towards the sea. Thus waters absorbed at high levels are often returned to the streams by natural springs at lower levels, and could be further made available by artesian wells, carried through the impermeable material to the water-charged zone beneath.

The older Carboniferous Rocks of North-western Yorkshire, called the Yoredale series by Professor Phillips, after the Dale of the Yore or Ure, constitute the area of waterfalls of South Britain, alternations of shale, limestone, and sandstone, repeat each other, and water is absorbed by "swallow holes," from the peat-covered uplands, which let down the water which would have swamped the surface into the limestone beneath, along which it travels, until the limestone is intersected by a valley, and the water tumbles over the limestone and shale beneath and forms a ready-made river.

Wells or shafts have been sunk in a few instances in England, but more numerously on the Continent, for the purpose of acting as artificial swallow-holes, such shafts are known as "dumb-wells," and can often be found to effectually drain a small property, at a fraction of the expense that would have been necessary to obtain an efficient discharge at a distant point. If ever they should be carried out on a large scale, they will materially reduce floods, and increase the dry-weather flow of streams.

The Millstone Grit series consists of an alternation of water holding, and water supporting material, allowing a very small proportion of the rainfall to be wasted, most of the percolation being returned as springs into the same river basin, and the shale forming an impermeable base for reserviors, it has given a valuable supply of water to all the great gravitation waterworks of the Northern Counties.

The shale causes the rainfall, which would otherwise have escaped in bursting floods, to maintain the dry weather flow of the streams, the size of the reservoirs is not excessive, owing to their being steadily replenished by springs. In nearly all the waterworks in these districts provision has been made for the wants of the mill-owners, formerly supplied by these streams, by the construction of enormous "compensation reservoirs," delivering, in the case of of Manchester, fifteen million gallons a day. Mill-owners have been enormously benefited in having a regular daily supply sent down to them, instead of having to depend upon the capricious volume formerly coming to them, influenced by climatic variations of draught and flood. In many cases, the provisions and engagements, entered into by Corporations with the mill-owners, appear to be too onerous, and were a "Conservancy Board" to be constructed, Parliamentary relief should be given from the penalty clauses for not being able to supply during years of exceptional draught, when it was the opinion of the Conservancy Board that the Corporation had done all that was reasonable to expect, and Corporations no longer compelled, after the compensation reservoirs were exhausted, to supply mill-owners with pure spring water, whilst human beings had to be put on short supply.

The amount of "average flow" of a stream will be found to be far below the volume that would be yielded by a third of the annual rainfall, and the disparity is still greater when the "dry weather flow" of the stream is compared with a daily average of one-third of the annual rainfall, pointing to the necessity of regulating the floods, which inflict a three-fold loss, first, by destruction of property in the lowlands; second, by depreciation of the value of agricultural produce, and the stoppage of manufacturing processes by its absence; third, the loss of vital energy, and the premature death of those whose business and occupations compel them to live in areas subject to floods.

When the far-reaching influence of uncontrolled water is studied, the constant drain that is made by floods on the health, life, and wealth of the kingdom will be realized, and the necessity of sweeping away the conflicting authorities that have control over our river basins admitted; these at present are multifarious in number, antagonistic in character, and often injurious in effect. The River Witham and its chief tributaries, for instance, is under the jurisdiction of 17 separate authorities, without including the various Drainage Commissions of the Fenlands, that would bring up the number to forty, while the River Lene, according to Sir John Coods, on only 30 miles of its course, between Peterborough and the sea, is overridden by no less than fourteen authorities.

Mill and Navigation Works affect rivers chiefly through weirs, obstructions fixed across a stream, with a view to prevent water passing on until it has attained a certain head; that height attained, its surplus water passes over the weir, in times of ordinary flow, with a more or less considerable fall. Landowners require a uniform top-level, neither too high to flood the meadows or too low to deprive them of moisture. Navigation requires the water to be penned back to make the upper reaches navigable, whether the land below suffers or not; whilst fishing owners maintain their right at their own convenience to raise the top-water to its highest limits, and then suddenly to depress it to its lowest limits, so that the fish may be caught in receptacles placed on the weir. Water-users pound up the water to obtain increased fall and volume, and draw it off by a mill-race, discharging it at the mill-tail; the water is often allowed to pound up the mill-head until it backs up the mill-tail of the works above, no thought being taken of the requirements of the works above and below, "flashes" of water being passed on without any consideration whether the works below can use it or not. The burden of all Royal Commissions on this subject, and the conçensus of opinion of all our eminent Water Engineers is, that without *central control* these varied interests cannot be reconciled. Weirs, properly constructed, would offer no obstruction to land drainage, but to carry this out the body exercising power over the river requires to be armed with the authority of Drainage Commissioners, so that in all cases districts receiving waters from above should have the corresponding rights of discharge into the districts below.

In Prussia, Saxony, and Bavaria the State authority claim absolute ownership of the water and navigable rivers, defraying the expense of their management out of tolls taken for use of the river for navigation, mill-power, and other purposes. On tributary streams riparian owners and townships are allowed to combine, on application, as a "conservancy authority," armed with powers to compel the construction and maintenance of the necessary works, and to tax those benefitted, but *not* those whose lands are beyond flood limits. Occasionally the State assists townships with pecuniary aid, and when the maintenance of navigation or the rateable value of land can be increased by the construction of an embankment, or the cutting of a new channel, the State defrays the cost of the undertaking out of the public funds.

In France, the Government undertakes the conservancy of all navigable rivers, at the expense of the National Exchequer. In the smaller rivers the embanking of lands against floods is carried out by "free syndicates," formed of adjoining owners desirous of protecting their property, and "authorized syndicates," with powers to compel the minority of land-owners to join schemes projected for the common good, the want of unanimity of opinion, causing many of the free syndicates to fail in their object.

Applying these facts to the British Isles, and especially to that portion of them that have come under the jurisdiction of the Local Government Act of 1888, calling into existence the County Councils of England and Wales, it appears to be necessary that there should be one authority for each river basin, with absolute control over its waters from their source to their tidal outfall, that such authority should be selected from, or nominated by the County Council of the county or counties forming the river basin, the number of representatives on the Board, being regulated by the rateable value of the portion of the river basin in the county in question, and not by its area.

Looking to the fact that the water used in this country for manufacturing and other trade purposes is so largely in excess of that required for drinking purposes, and that the value of a large area of land is in direct proportion to its facility of giving the water required by industry, it is inexpedient that there should be any interference with the riparian rights of ownership, now exercised by Lords of the Manor, so long as such rights do not interfere with the public good, but the control of these rights might be safely left in the hands of a body acquainted with local requirements, appointed by the County Councils as suggested. Such a representative Board would be able to benefit land-owners far more than they could benefit themselves, having control of the whole of the river gradient from its source to its outfall, they would be able to maintain our rivers at sufficient average minimum height to insure free arterial drainage, and the regulation of floods at a sufficient maximum height to originate hydraulic energy when required, and for the purposes of navigation, and of sufficient purity to satisfy the requirements of water supply, manufacturing processes, and the preservation of fish.

Provision for concerted action of county authorities in the same river basin has already been provided for by the Act of 1888 as regards *Rivers Pollution*, if Parliament should give them similar powers as regards *Rivers Conservation*, the first step towards the amelioration of the evils caused by flooods will have been taken.

In March, 1883, a Bill was proposed and brought into Parliament by Mr. Dodson, Sir Charles Dilke, and Mr. Hibbert, for what was called "Rivers Conservancy and Floods Prevention Bill," which did *not* become law. The Bill did not recognize the absolute control of a river basin, it proposed that an Inspector of the Local Government Board should hold a local enquiry, and ascertain what "lands ought to be described as lowlands, midlands, and uplands,"... "and what works, if any, have been executed for the protection of any such lowlands, or midlands from floods, and in what proportion such lowlands and midlands ought to respectively contribute to the expenses of the Conservancy Board, and what uplands, if any, ought to be included in the district, and in what proportion they ought to contribute to any expenses of the Conservancy Board."

And it would have further been enacted, that "the highest rate in the pound payable by any uplands included in the district shall not exceed *one-tenth* part of the rate in the pound payable in respect of the lands in the district which pay the highest general rate, regard shall be had to the extent to which any artificial drainage works for such uplands contribute to cause, or aggravate floods within the district."

In the projected Act of 1883, no provision was made for a scientific examination of the district, previous to or during the Local Government Enquiry, or the record of flood levels, the amount of rainfall, the amount of absorption, or any other data that would be useful to the Inspector appointed, in proportion to the time the observations had been taken. No definition was given of the difference between uplands and midlands, or the reason why the river basins were not divided into "areas not flooded," and "areas subject to flood," judging by some sentences in the projected Act, the "midlands" referred to areas only occasionally flooded during the flow periods.

Should Parliament pass a Bill, enacting that a "Conservancy Board" be appointed for each river basin, nominated by the County Councils within that basin, before they commence their active operations, it will be necessary that the Surveyor or Engineer obtain for them reliable information, as to the heights of floods, and that levels should be recorded on the six-inch County Maps of the Ordnance Survey, such information would be greatly enhanced in value, if a record was taken daily of the height of streams on all the county bridges, such observations could be readily obtained, if gauges were painted on them in white and black, giving the height in feet above the Ordnance datum, of the mean sea level, to facilitate comparison, and the height of the water upon them was daily noted by the county Constabulary on their ordinary rounds. On important points self-recording apparatus to ascertain the daily quantity of water carried down might be placed, under the direct supervision of the Board's official, who should organize a system of flood warnings by telegraph.

In the meanwhile much valuable information may be rescued from oblivion by observers, who will note the height marked by floods at important points, and the height in reference to the Ordnance datum given, date and local circumstances recorded. If such a work were undertaken by the leading provincial societies a valuable map of facts would soon accrue. I venture to think it is also the duty of scientific societies to urge upon the government the necessity of Parliamentary power being given to the county councils; to sanction the small charge that would have to be made on the water; to fix guages on the county bridges; to inaugurate a system of flood-signalling, and to make such contributions, regulated by the area included, as would give funds for the inspection of rain-guages, and the tabulation of the averages of the rainfall of the district over which the Board has control. Were such a map of facts in existence the Rivers Conservancy Board, when appointed, would have a tangible foundation on which to improve their districts, increase its wealth, and preserve the health of its inhabitants.

Whether it is advisable or necessary that there should be a responsible official of the crown in one of the Houses of Parliament, whose duty it should be to represent riparian requirements, is a matter almost beyond that of subjects appertaining to a scientific society, but that the necessity of control of our rivers should be vested in a representative body chosen from the district, and knowing its requirements, rests upon a scientific basis.

Percolation of Rainfall into the Ground:—Experiments were made simultaneously by Dr. Dalton at Manchester, and by M. Maurier at Genoa, in the years 1796 to 1798. Dalton's guage was a cylinder 10 inches in diameter, and 3 feet deep, open at the top, closed at the bottom, filled with earth, and sunk into the ground until the top was level with the surface. He found 25 per cent. of the rain to be absorbed. These observations were probably taken with the soil resulting from the decomposition of vegetable matter mixed with the stiff Lancashire Boulder Clay. M. Maurier's observations gave the larger figure of 39 per cent; while the very careful observations taken by Mr. Dickinson between 1836 and 1843 at Nash Mills near Hemel Hampstead, Herts., gave 42 per cent.; this is with a chalky porous soil. The Nash Mills observations have been continued to the present time by Mr. Dickinson's partner, Dr. Evans F.R.S.

The gauge, on two cast-iron cylinders, 18 inches in diameter, and 3 feet in length, turned to a knife edge on the top, are sunk to a depth of 3 feet below the level of the ground in which they are placed, so that the edge just projects. One of the cylinders is filled with the ordinary surface soil of the neighbourhood, and the other with fragmentary chalk. Grass on and around the cylinders. The rainfall is observed in the immediate neighbourhood of the gauges, and the register is made up at 9 a.m. The year is divided into two, the winter half commencing 1st of October, and the summer half 1st of April.

The following figures give the average for 30 years :—

Winter.			Summer.		
Rain.	Soil.	Chalk.	Rain.	Soil.	Chalk.
13·02	5·20	7·79	13·35	0·65	1·71
Annual average :—			26·38	5·85	9·51

The varying capacity of soils for the downward transmission of water is well-shown in the above table, but Dr. Evans points out it is doubtful whether a 3 foot tube is a fair test of the water that would really make its way down to feed the chalk water, as it is possible that atmospheric influence may reach even 10 feet, and may be drawn up by capillarity within the limit of superficial evaporation.

Mr. Green's observations at Lea Bridge from 1852 to 1873, with an average rainfall of 26·8 inches, gives an average percolation of 26·6 per cent. He finds the abundance of water, in a river, to be more closly dependent on percolation than on mere rainfall; for many consecutive months there was no percolation whatever; five times there was no percolation for six months; and only in one year (1860) was there percolation every month. The greatest percolation is after snow thaws, especially after frequent thaws of small falls. A wet winter gives abundant springs in the following autumn, but if that be followed by a dry winter it will obliterate the effects of the previous wet winter. Mr. Greaves is of opinion that a flat soil will never produce a flood if it be effectually under-drained, as it then resembles the percolation gauge; such under-draining would diminish floods, and the water would be run off gradually and improve the dry-weather discharge. Mr. Greaves considers a percolation gauge should be 36 inches deep, and at that depth that water is safe from the surface loss. He suggests that in the different degrees of capillarity of different soils lies the cause of their variations in healthiness, the high capillary power of a clay soil producing a constant summer exhalation.

Underground Water Supply:—Pervious or permeable formations, by gradually absorbing waters falling on the surface, which slowly percolate through them, act at once as filter-beds and as reservoirs, the capacity of which is limited by the area of absorption, and the thickness of the pervious bed. When rain falls upon a pervious rock overlying impermeable deposits, the water-line is generally near the surface, and forms the "plane of saturation" which is found to be slightly above that of the deepest valley intersecting the water-bearing rock, rising towards the centre of the hill, varying within certain limits, being governed by the amount of previous rainfall. When wells are sunk into it, and excessive pumping takes place, the plane of saturation is artificially and locally lowered, and is known as the pumping level, after a few hours cessation of pumping, the water rises to its original level, or nearly so, the point so reached is the "rest-level." The difference between the "rest-level" and the pumping level in some wells is as much as 100 feet. The area of exhaustion resembles an inverted cone, the apex of which rests on the point at which the pumps abstract the water, and the base of which is a circle at the surface around the well. If over pumping takes place, the "cone of exhaustion" has to be increased, its vertical height increases by lowering the pumps to a lower level, and a larger concentric circle is added to the central one at the surface. At each successive lowering of the pumps, a larger concentric circle of contribution is added to the original area of abstraction. Wells of this class are not artesian, and the water in them does not rise at pressure. In porous rocks of great thickness, the plane of saturation is often at a considerable depth from the surface, the annual rainfall absorbed being balanced by the springs running off at the lowest level, but little being collected from the floods, the water passing over the outcrop of the porous strata too quickly to sink into the strata. In these cases it would be possible to raise the height of the *saturation level*, increase the storage powers of the rock, and the yield of the springs by sinking "dumb-wells" into the porous strata, and draining the storm-water channels into them, in this manner the floods of wet periods may be collected, and distributed as springs during periods of drought, and the "dry-weather flow" of the streams increased.

When Sandstone or Grit is examined under the microscope, spaces are seen to exist between the grains of sand forming the rock. The size and extent of these spaces limit the capacity of the rock for *water storage*, water being stored in the interspaces just as water is stored in a tank full of shingle, into which water has been poured. The amount of water that can be held by a rock varies with the proportion of its cubic contents, that is made up of interspaces; a cubic foot of sand or chalk will hold 2 gallons of water, a cubic foot of Bath Oolite a gallon-and-a-half, while a cubic foot of granite 0·185, or a pint-and-a-half.

One inch of rainfall equals 1 gallon, filling over 2 square feet, or 22,427 gallons per acre, or 14,355,280 gallons per square mile. Such a rainfall spread over a year of 365 days, gives a daily average of 62 gallons per day per acre, or 40,000 gallons per day per square mile. The amount that can be absorbed by the porous rocks varies from 5 to 15 inches, and may be said to average 10 inches in sandstone, giving 400,000 gallons per day per square mile. This figure is a useful one in estimating the probable yield of a well.

In limestone the quantity of water held by a given mass of rock also varies with the size of the infinitely fine grains making it up, the available quantity for waterworks purposes is chiefly that stored, or passing through circles, joints and fissures, whilst the remainder of the water held in the mass occurs between the particles, for the retention or abstraction of which there is a constant struggle between capillarity and gravity, and though the water is received with great rapidity, it is parted with, with exceeding slowness. It is important to distinguish between the amount of *storage capacity* and the actual volume annually *absorbed* from rainfall, the one appertaining to water capital, the other to water revenue.

When bands of permeable and impermeable rocks alternate, each porous band contains a separate sheet of water, which flows down the "dip planes" of the strata confined by the impermeable layers above and below. Such water flows with the "head," due to the difference of vertical level of the "area of outcrop" to that of the "area of discharge," less the frictional resistance of the fragments of the rock through which it passes. When the facilities for the discharge of a volume are less than the quantity capable of being received, the porous rock will be full up to the impermeable layer above, which is invariably the case when all outlet is stopped by faults throwing in impermeable strata, or by the dip carrying the strata beneath the sea-level. Such porous rocks may be regarded as underground conduits, the depth of which is the thickness of the bed, the width of which is the extent of the outcrop or horizontal strata of its bed, and the inclination of which is the dip of the strata. When the outlet is blocked the saturation level remains unchanged, and unless water is artificially removed, so as to provide space for a fresh supply, no additional water can be added to the existing supply.

From the investigations I made in 1878 as to the area of the various rocks in each river basin in England and Wales, which form the basis of the paper read before the Water Congress convened by the Society of Arts, at the instigation of their President, H.R.H. the Prince of Wales, I estimate the area in England and Wales, occupied by porous rocks, at 26,633 square miles; whilst the clays of the tertiary, gault, weald, oolite and lias, the marls of the trias and Permian, the shales of the carboniferous, occupy a further 19,308 square miles, forming for the most part a "supra-pervious area," or one which, though impervious, overlies *pervious rocks*, that can be drawn from by artesian wells, or discharged into by dumb wells, into which the land-drains might discharge, and replete the strata beneath with water that would otherwise have passed off as devastating floods, and thus increase the summer discharge of the streams, and turn the intermittent springs into springs of permanent value.

Should dumb-wells become common it will be necessary to use great care that communication is not set up between drains carrying objectionable matter and the underground sheet of water, and that in drawing water from wells and bore-holes that the point at which the water is abstracted is sufficiently removed from the surface to insure the water being naturally filtered by passing through the superincumbent strata.

The alternating character of the Millstone Grit, of permeable and impermeable material, and the deep ravines with which it is generally intersected render it peculiarly suitable to the sinking of dumb-wells in the shale areas, to conduct the rainfall of the impermeable portion down into the porous rocks beneath when it can be stored. They are also valuable for giving a pure and permanent supply of water to wells and borings, there is strong reason to believe that Underground Water from this source will be more and more utilized, and this would be still more likely to be the case if the natural percolation into the porous outcrop were aided by dumb-wells through the impermeable cover. Reservoirs having to be constructed of large size, to enable them to last out droughts, necesssarily occupy a considerable area of the best land in a hilly district, often of a character well suited to provide food stuff for cattle, a matter of great importance in a country containing so small an area as England, and consequently obliged to import a large portion of its food supplies.

The Coal Measure Sandstones of Yorkshire often yield good supplies of fresh water, when not contaminated with water from coal workings; the water so derived is bounded by faults, which divide the country into water-tight compartments. The fissure of the faults, traversing strata of an impermeable nature, becomes filled with it and constitute a water-tight barrier.

The Triassic and Permian formations of England and Wales are capable of yielding not less than a daily average of 3,000 million gallons of water, of a quality remarkably free from organic impurity, and the hardness of which does not in the least appear to affect the health of the population at present taking their supply from it, the death-rate of hard-water areas, other things being equal, comparing well with soft-water areas.

Referring to the New Red Sandstone Rock, the Royal Commission into the Pollution of Rivers (6th Report Domestic Water Supply) states, it constitutes one of the most effective filtering modes known, and being at the same time a powerful destroyer of organic matter, the evidence of previous pollution in water drawn from deep wells in this rock may be safely ignored, "for being a porous and ferruginous rock, it exerts a powerful oxidizing influence upon the dissolved organic matter which percolates through it. To such an extent is this oxidation carried, that in some cases, as in those of the deep well-waters supplying St. Helens and Tranmere, every trace of organic matter is converted into innocuous mineral compounds."

The Commissioners further add, that though the quartz sand constituting the bulk of the New Red Sandstone is usually cemented together by carbonate or sulphate of lime, the hardness of the water is generally moderate, and of a nature that can be softened by lime, and they state that "unpolluted waters drawn from deep wells in the New Red Sandstone are almost invariably clear, sparkling, and palatable, and are amongst the best and most wholesome waters for domestic supply in Great Britain. They contain, as a rule, but a moderate amount of saline impurity, and either none, or the merest trace of organic impurity. There is every reason to believe that a vast quantity of hitherto unutilized water of most excellent quality is to be had at a moderate expense from this very extensive geological formation." The truth of these statements has been amply proved by the labours of the Underground Water Committee during the past sixteen years. It is here needless to point out the millions of gallons of pure water that are daily pumped for the public supplies of Birmingham, Nottingham, Liverpool, Birkenhead, Southport, Coventry, and the Staffordshire Potteries.

It is worthy of note, that faults in those portions of the New Red Sandstone, which are traversed by thick shales or rocks, are filled with porous material, and do not offer any obstacle to the passage of of water, and it is only when the Keuper rocks are either present, or have been just overhead, but since removed by denudation, that the faults form into barriers.

The Yorkshire oolites form a valuable source of pure underground water, while the Yorkshire chalks offer an area of absorption of no less than 420 square miles, and has been carefully studied by Mr. J. R. Mortimer. A considerable area of oolitic rocks occur in Yorkshire, and their exceedingly permeable character causes them to absorb a very large proportion of the rainfall, which charges the pores and fissures with immense volumes of water of an average hardness of 23·52 grains per gallon, but capable of being softened at a moderate cost to 5·8. Vast stores of magnificent water are thrown out in springs of very large volumes, which are seldom used by communities until it has found its way into rivers, and becomes polluted. The temperature of these springs ranges from 8°1 to 11°8. The proportion of organic matter yielded to dumb-wells in this formation is exceedingly small, proving the Oolitic Rocks are not inferior to the New Red Sandstone in the energy with which they oxidize and destroy the organic matters present in the water percolating through them, which becomes bright, sparkling, palatable, and perfectly wholesome.

The alternating character of the Oolitic Rocks of Yorkshire have had an important bearing on the selection of the sites of villages, thus Mr. Fox-Strangways* remarks that "on either side of the great clay valley, where springs of beautiful calcareous water bursts out, are on the north, the villages of Witton, Allerston, Ebberston, Stainton, Brompton, Wykeham, Hutton, Buschel, Ayton, and Seamer; and on the south those of Rillington, Thorp Basset, Wintringham, Heslerton, Sherburn, Ganton, Flexton, Folkton, Hunmanby, and smaller hamlets.

The chalk absorbs the largest proportion of the rainfall of any rock*, yielding it in deep wells in a condition of purity from organic matter unsurpassed by any other geological formation, and it constitutes a vast underground reservoir in which the water is not only kept pure, but is kept at a uniform temperature of about 10° C (50° F.), rendering it cool in summer, and keeping it far from freezing in winter. Every million gallons of water drawn from the chalk carries with it in solution, on an average, 1¼ tons of the chalk through which it has percolated, causing an additional storage room for 110 gallons of water, so that the yield of a well draining a given area, other things being equal, ought to gradually increase in yield until the maximum limit of permeability is reached.

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* Geol. Sur. Mem. On the country around Scarboro' and Filey.

The Chalk of Yorkshire is drained over 364 square miles by the river Hull, 90 miles by the Derwent and Foulness, while 88 miles drain northwards and eastwards to Flamborough Head and Bridlington Bay, and 206 miles southwards into the mouth of the Humber. Much of it is heavily covered with the thick Glacial Drift of Holderness, chiefly consisting of impermeable clay, from 50 to 200 feet in thickness, their surface rising to 109 feet above the sea, their base sinking to 130 feet below it. The chalk, according to Mr. J. R. Mortimer,* is 800 feet thick, and rests on impermeable neocomian or Kimeridge Clays. It is subject to the curious "Gypsey Races," local temporary autumnal rivers, corresponding to the "Bourns" of the chalk of the South of England.

In my work on "The Water Supply of England and Wales," published in 1882, I have attempted to show what is the probable supply of water available in all the river basins of South Britain, and what is the amount required to satisfy the demands upon that supply, with the result that it appears to be amply demonstrated that the rainfall of this country is more than sufficient to meet all the requirements of human consumption, manufacturing processes, and the purposes of canalization, and yet with these resources large districts still suffer from all the ills of polluted water supply, whilst other areas are devastated by floods, representing unproductive rainfall passing to the sea. In no county would this unproductive rainfall be more valuable than in that of Yorkshire, where water is not only wanted for human consumption, but for the varied processes of trade, and nowhere could it be more largely increased by dumb-wells in the manner suggested.

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* Min. Proc. Inst. C.E., vol. iv.

PRE-HISTORY OF THE VILLAGE OF FIMBER : PART I.

BY J. R. MORTIMER.

Every town and village has an unwritten history to be deciphered, and the writer hopes that his feeble attempt in this instance will induce others, far more able than himself, to make known any still remaining archæological features belonging to localities best known to them. He believes a few more papers of this kind, notably such as those given by Mr. Holmes and by Mr. Davis in Vol. ix., would do much to increase and spread a knowledge of the early history of Yorkshire, and not in any way detract from the merits of the Society's Proceedings. Though, probably, its chief purpose is to advance geological research, the field for geological study will, in the main, be as readily investigated in a thousand years hence as now, and there is no need for anxiety; not so with the works of early man sculptured in various forms on the earth's surface. Modern civilization, and its inevitable surface mutilations, often miscalled improvements, have necessarily removed the greater portion of the old works and ideas of the early ages of man, and but a very small proportion of what once existed now remains. These also will soon be lost for ever if not deciphered and recorded, hence the value of encouraging archæological pursuits, and offering facilities for noting and preserving the few remaining works of the distant past.

Fimber is pleasantly situated on what we may term a rampart-girt natural eminence, in a picturesque depression on the eastern side of the Chalk hills. At what period man was first domiciled on this spot will never be ascertained, but the evidence we possess carries us far back into its past occupation.

During the last 26 years I have (often assisted by my brother, R. Mortimer) excavated the barrows and every kind of ancient earthwork in its vicinity which were likely to yield any information on the forgotten past, and it is mainly by the aid of the pick and the shovel that I have obtained the interesting information which forms the subject of this paper.

As I have already intimated Fimber is a place of great antiquity.

It is situated within a large entrenched enclosure, the plan of which is given in pl. viii., and most probably it was one of those British fortified towns (Oppida) described by Cæsar as places of refuge, viz., "points naturally strong by reason of difficult ground, marshes or "wood, and still further secured by mounds and ditches. To the "ample area thus protected cattle and men retreated from hostile "incursions."*

This entrenched enclosure is one of several similar enclosures on the adjoining hills, and to which it has been linked by the same kind of ramparts and ditches. But as the Rev. E. M. Cole, a short time ago (Vol. xi., Part 1), gave a very interesting paper on this class of entrenchments, illustrated with a plan on which he traced a few of these entrenchments over a considerable area of this neighbourhood, and as my brother has published a map showing their form and arrangement in the neighbourhood of Fimber, it is not necessary I should describe them further in this paper. But in addition to this system of ancient earth-works, which is not later than those named by Cæsar, are the remains of others and even older earth-works, which unfortunately have hitherto been included with the entrenchments proper.

The accompanying plan, pl. viii., shows six of this class, to which I give the name of 'hollow-ways' or covered-ways, converging towards the village of Fimber. On the uncultivated hill-sides they now have the appearance of narrow terraces, but wherever the ground has been long tilled no visible trace of these hollow-ways remains; but it is almost certain that they all approached as near to the village of Fimber as the western end of No. 5 has been traced to; whilst very probably a similar sunk-way, all surface trace of which has been removed by long cultivation of the land, ran southwards between Nos. 1 and 5. In excavating near the church the end of such a trench was discovered pointing in that direction.

During 1863 to 1880 I obtained many sections by cutting across each of these hill-side ledges at several points, and in every case they were found to be V-shaped trenches (see sections, fig. 2) 3 feet to 4½ feet deep, and measuring from 8½ feet to 16 feet wide at the

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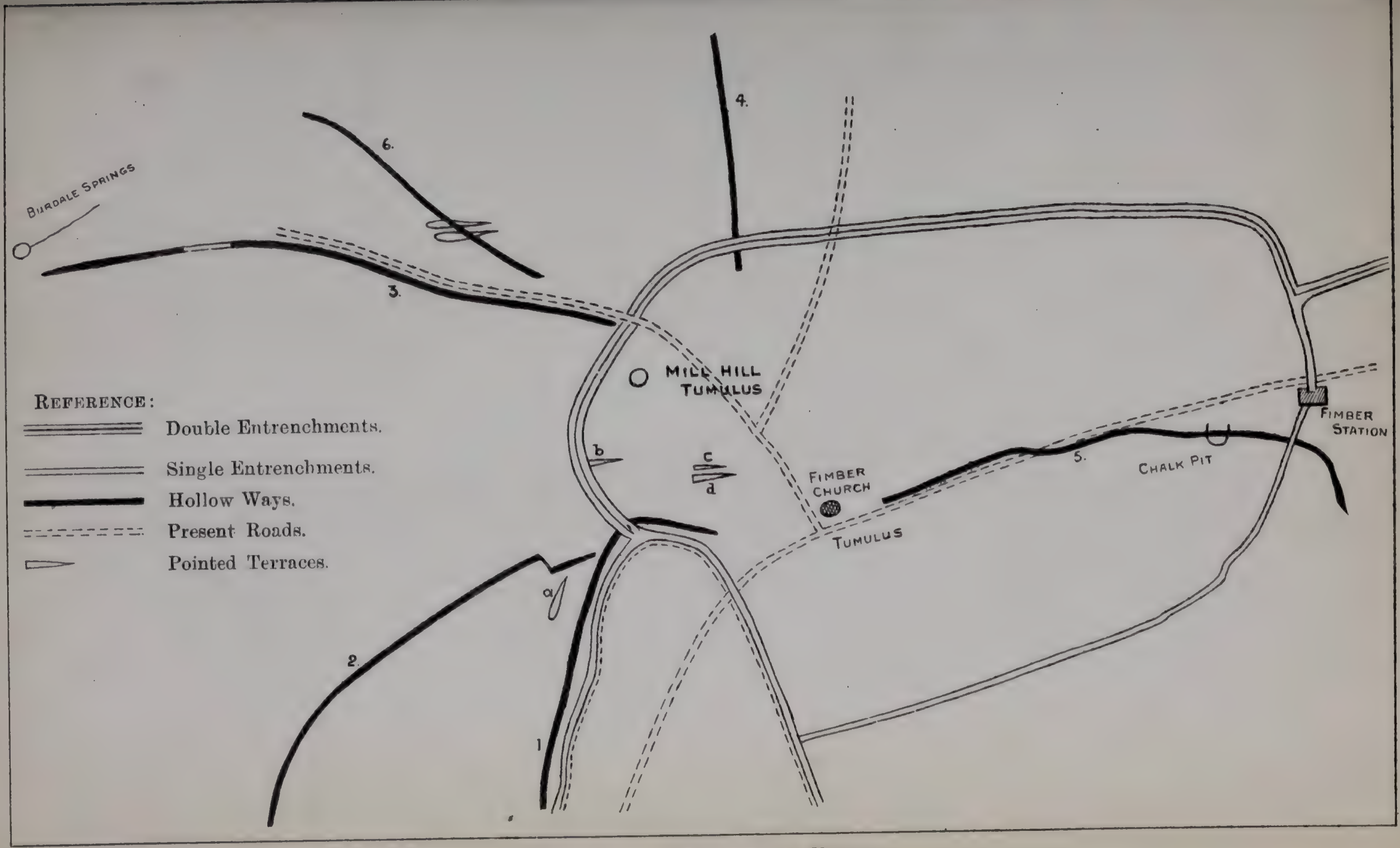
* Bell. Gall. v. 21.



Mortimer: Pre-historic Fimber.

top, and from 18 inches to 3 feet at the bottom, the excavated material from which now slightly raises the natural contour of the hill-side along their lower edge, and originally may have been sufficiently high to cover from sight a tall man while passing along the bottom. The lower halves of these trenches were found to be filled with small chalk grit which had been slowly removed from the hill-sides above by rain and frost, and the upper portions were charged with soil-like matter. A short description of each hollow-way will throw some light on their use, show the uniformity of their plan, and enable their positions to be made out on the 6-inch Ordnance Maps.

No. 1 is visible for three quarters of a mile, running midway along the S.W hill-side of "Rain Dale," and about a chain-length below the entrenchments, locally called double dykes, which run along the brow of the hill-side. At its bottom we observed two to three inches of gritty matter, comparatively hard and compact as if from having been frequently walked upon,

No. 2 branches from No. 1 at a point on the 6-inch O.S., marked by the letter "e" in Rain Dale. It crosses the east end of "Wan Dale," and is visible midway between the northern side to the western termination of this dale.

No. 3 is distinctly shown for a short distance dividing, equally, the hill-side called "Haggdale Cliff." It faces the south side of the railway, half way between Fimber and Burdale stations, and can be seen from the train. From here it is traceable in places as far as Burdale, and is well shown terminating there on the S. W. hill-side, near a fine spring of water, (about 2 miles from Fimber) to which it probably led, there being no other spring of water within twice the distance from the village of Fimber.

No. 4 strikes nearly due north from Fimber, then swerves more easterly towards the old settlement of Towthorpe, but only begins to be distinctly traceable on the surface at the southern end of "Big Dale," on the eastern hill-side, where it is cut across by a double dyke, (entrenchments) running vertically up the hill-side in the direction of Sledmere. June 8th, 1863, the Section, pl. ix., fig. 4, was taken about 200 yards north of the entrenchments, and on August 29th, 1865, we made an excavation into the north side rampart of the entrenchments, and obtained a similar section of this hollow-way extending under the rampart, clearly proving it to be the oldest of the two.

No. 5, except being seen at times as a green strip in the growing corn, can only be traced by excavating, all surface configurations having been removed by the often repeated tilling of the land. In tracing its position we took more than 20 sections, and the one nearest the village was taken a few yards north-east of the most easterly mere in the grass field close to the north side of the road to Sledmere, and its position on the 6-inch O.S., is near the letters "se" in "Manor House." From this point it runs eastwards close to the north side of the road to the bottom of the hill, a distance of one-sixth of a mile, or 1 inch on the 6-inch map, it then crosses the road obliquely and runs by the south side of the road, where it is cut by a chalk pit, from the opposite sides of which the sections, pl. ix., fig. 5, were taken; it then gradually rises the hill-side, and on reaching a point opposite Fimber station, is crossed by the British entrenchments shown on the plan, but now almost equally obliterated. From here it sweeps round "Cole Nab," and was found extending one-sixth of a mile, and probably might be traced further.

No. 6 rises obliquely, the ground sloping to the south, cultivation has removed all surface configuration of these trenches, but at times they are distinctly visible in the maturing crops by a line of deep green corn growing on it, see plate ix., fig. 6, one of three taken, in all of which we found fragments of Roman, or Romano-British pottery, but in no case below half the depth of the trench. This sunk-way possesses additional interest by crossing two narrow terraces, (a paper on these terraces is given in vol. ix.) see fig. A, plan 2. At this point an excavation was specially made across this covered-way, and one of the terraces at the point of intersection, with the view of proving, as far as possible, which was the oldest, and all the appearances of our section seemed to show that the terrace had been made the first.

Nevertheless, the hollow-way was proved to be of great age by the finding of fragments of hard Roman pottery in all the three excavations, but in no case below half its depth, indicating that this trenched road had been disused, and half filled up by slowly accumulating *debris,* before the potsherds had found their way into it. This is strong proof that it was constructed in Pre-Roman times. Besides the above evidence of the antiquity of these sunk-ways we find the two, marked Nos. 1 and 4, are sharply cut by the old entrenchments which enclose the village of Fimber, and Nos. 3 and 5 appear to afford similar evidence; these are unquestionably ancient British, thereby proving that these sunk-avenues are older than the entrenchments, and that they belong to a period of still more primitive culture.

They have, at some remote period, been excavated, and almost certainly used as roads, leading in nearly every direction to and from a small, and probably rudely entrenched settlement, the site of which is now occupied by the little village of Fimber; and the demolished barrow, pl. viii., on which, as will be shown, three succeeding churches have stood, was probably within this enclosure; indications of such an enclosure seem yet to remain in places.

In a wild and wooded district these narrow sunk-ways would be safe and sure guides by day and by night to a rude settlement, to which they undoubtedly lead. They would also protect the primitive settlers during their travels in what was probably then more or less a forest, against sudden attacks of the wild and ferocious animals of that period, which would not choose to enter these narrow trenches. They would likewise assist the hunter to approach unobserved, any animal in the vicinity, he wished to capture; and any large game he might surprise and force into these narrow and deep ditches would have great difficulty in extricating itself, and might be readily driven along the ditches into the central and inhabited enclosure, where its capture would be more easily accomplished. Lastly, they unquestionably denote the fixed settlement of a rude and primitive commune in pre-historic times, earlier even, as before named, than the period of double dykes (entrenchments), of which, let me remark, there is no written or oral history, and whose use is entirely forgotten.

Still older than these hollow-ways are what the writer terms "Habitation Terraces," generally situated on the sides of deep valleys facing the morning or mid-day sun, a few of which exist near

Fimber, and are shown on the accompanying plan by blue patches of a wedge-shape, which in some instances are shown to be, as previously mentioned, intersected by hollow-ways. A description of these terraces will be found in Vol. ix., Part 2, of the proceedings of this society; whilst, probably, equally as old as these terraces, or even older, as we have not as yet, had means of determining the relative age of the two, are the tumuli in the immediate vicinity of this village. I will give an account of two of these to show the intimate connection they have had with the pre-historic inhabitants of this place.

The first barrow is known by the old inhabitants as "Mill Hill" (which name, in this place, is probably a corruption of "Mall Hill" or "Moot Hill," as there is no tradition that a mill ever stood upon it); it measured 45 feet in diameter and about 2 feet in elevation, and was composed for the most part of unwaterworn chalk gravel. It is situated about a quarter of a mile to the west of Fimber, in a field called, by the old residents, "Mortar Pits," from its being the site of extensive old pits from which a small unwaterworn chalk gravel, mixed with pulverized chalk, was at one time obtained, and extensively used as mortar for building the stone walls and laying the floors of dwelling-houses and other buildings erected in the neighbourhood.

We commenced to open this barrow first by a trench, 9 feet wide from its southern to its northern margin, and observed the ground to have been disturbed to a depth of 4 feet, from which we took fragments of mediæval and other pottery, pieces of corroded iron, teeth and bones of animals, all mixed in great confusion with the substance of the mound from base to apex. We next made a second trench, 5 feet wide, adjoining and parallel with the west side of the first opening. Afterwards a similar trench was made on the east side of the mound, also adjoining to and parallel with the first opening. These, like the first excavation, yielded teeth and bones, potsherds and corroded iron, which were also dispersed throughout the excavation in a similar confused manner; whilst near the western margin, about 1 foot below the surface of the barrow, we took a small bronze buckle and a pretty little stud of the same metal, which had been riveted to some thin substance. A few flint flakes were also found. In looking over the potsherds four kinds were readily observed.

The first consisted of a few pieces of rather small vessels of a dark texture, very like the Roman black-ware, and free from glaze.

The second kind are larger pieces, of a coarse brown colour, some portions of which are glazed and seem to belong to vessels somewhat resembling the common pancheons now in use.

The third kind contains many pieces of a thin unglazed ware, made of red clay, the inside of which, to about half its thickness, is burnt black.

Lastly, there are many pieces clearly belonging to several vessels of various sizes, all of which possess a beautiful green glaze, and have a whitish texture.

The corroded iron consists for the most part of nails, some of which have rather large flat heads, and others have small heads, similar to some of the kinds now in use. There are also four bent pieces, resembling the sides of buckles, or staples, and four flat pieces, two of which appear to have had holes through them ; and the other two look like portions of knives or spear-heads. The most recognisable bones we possess from this mound are chiefly teeth of the horse, cow, and the goat or small deer.

After a few years increased experience in barrow digging, we believed that a further examination of this mysterious mound would throw some additional light on its lost history ; we, therefore, on May 12th, 13th, and 14th, 1870, conducted a most careful research, commencing on the southern margin, and presently noticed a well-defined disturbance in the ground under the mound, running towards the centre. In following this old excavation we observed, on reaching the centre of the mound, that it branched to the east and to the west, and also extended towards the northern margin, thus forming a complete cross-formed excavation, with equal arms, cut through the mound into the ground below, and charged with dirty gravel. This gravel, like that from the mound above, was found to be mixed with great numbers of potsherds similar to those I have described, broken animal bones and teeth, bits of burnt and decayed wood, and much oxidized iron, chiefly nails of various sizes, some adhering to bits of decayed wood, apparently oak. There were also a small bronze buckle and other bits of bronze. Down the centre of this cross-formed excavation, at a depth of 4½ feet, ran a walled cross, pl. ix., fig. 8, composed of two and in some places three courses of thin stones, the interstices filled in with chalk gravel, and a little clay obtained from a distance (the centre of Fimber being the nearest place from whence it could be obtained). Each arm of this walled cross was about 8½ feet long, 16 inches in width, and from 8 to 10 inches high. The stones composing it were mainly of chalk, some of which had been slightly dressed, and there were also a few bits of untooled liassic and oolitic stones. Below this walled cross the excavated cross extended downwards, and was also charged with gravel discoloured with a little soily matter, containing, but not so numerously as the above, potsherds, bits of animal bone, iron nails much rusted, and, what is still more interesting, some bits of a British food vase. This excavation reached to a depth of 9 feet, and at the bottom each arm measured 10½ feet from the centre of the cross excavation, and nearly 4 feet in width. On the bottom, which was undisturbed angular chalk gravel, was a second, plate ix., fig. 9, unfinished, or partially destroyed (probably during some party contention, religious or secular) walled cross also mainly composed of rough pieces of chalk stone, with occasional bits of liassic and oolitic rocks, interspersed with clay, which seemed to have been used as mortar. This structure measured 18 inches wide and 8 inches high where it had not been injured, and its arms were a little longer than those of the more perfect cross 4½ feet vertically above it.

The age of these crosses is uncertain, but probably they date from late Roman through Anglo-Saxon, and were in use up to early mediæval times as places of assembly, (a few similar crosses have been discovered in other places near old settlements) whilst the discovery of flint-flakes and bits of a British vase indicate the site of a British barrow and the breaking up of a British interment, whilst the pieces of lias and oolite may have been portions of the slabs of a cist, which, with its contents was destroyed at the time of digging the cross-shaped excavation, which completely occupied the centre of the mound. We also noticed places where patches of the original British barrow seemed to remain undisturbed.

The next Barrow is situated on the terminal end of a natural eminence of the chalk rock called Church Hill, in the centre of the village. Its discovery was made June 4th, 1869, while taking down the old church, and excavating the foundations for a new one, about to be built by the present Sir Tatton Sykes, Bart., who has, with great liberality, built and restored several other churches in the neighbourhood. At the same time traces of the foundations of an earlier and larger church than the one just taken down were here and there observed.

The *dèbris* of this early church was in some places 18 to 20 inches in thickness, and contained numerous small pieces of burnt wood, and towards the west end bits of stained glass, and a considerable quantity of melted lead, which had in places run into small openings and cavities in the *dèbris,* giving strong proof that this early church had been destroyed by fire. It was also then shown that this early church had stood upon an artificial mound, apparently an oval barrow, consisting of horizontal beds of clay, interspersed with horizontal patches of loose flint-stones of various sizes. These had been obtained from the surface of the surrounding land, whilst the clay, which at first we mistook for a natural bed of " Hessle Clay " capping the chalk, had been obtained from a bed of clay filling a hollow in the surface, and now the site of two fine meres, which adorn the centre of the village.

Probably the obtaining of this clay for building the barrow, and bedaubing the wattled huts of that and succeeding periods,* left the hollows which in part now form the beds of the present meres. This supposition has been supported. During the very dry summer of 1826, an attempt was made to remove the mud from the large oval and most easterly mere, but when about half completed the weather suddenly changed, and a violent thunderstorm put an end to the operations by covering the bottom with about 2 feet of water.

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* Even some of the partition walls in the interior of the old house in which the writer was born, an interesting old place, now consists of clay obtained from the localities of these meres, mixed with a little short straw, and it is known that originally its outer walls also, as well as the walls of most of the other old houses in the village were at first entirely composed of this clayey substance, which is found in no other place nearer than the village of Fridaythorpe, a distance of nearly two miles, where also a bed of clay is the site of two meres in the centre of the village, and there are other instances.

But in the dry summer of 1884 the water was sufficiently low to enable the villagers to remove from this mere the whole of the mud which had accumulated during untold ages along its centre to the depth of 3 to 6 feet. This exposed the original irregular bottom, which much resembled, in places, shallow pits from which clay had been at different times taken. The finding, about 2 feet down in the mud, an iron spear-head, probably Anglo-Saxon, or possibly Romano-British, goes far to prove that this portion of the mere had not been cleaned for many centuries.

Returning to the barrow. At the west end of the church pl. ix., fig. 10, under the site of the old tower, at a depth of 5 feet below the present surface, and about 3 feet below the *dèbris* of the original church, the workmen came upon animal bones, carbonized wood, and lastly, after having dug up a small flint axe and apparently destroyed three small vases, they made the find known to the writer. On arriving at the place we found that the workmen had reached within a few inches of the bottom of a grave cut a little way into the chalk rock, and after a careful search we found further portions of two food vases and part of a drinking cup having a wide base ; also small bits of the finely ornamented rim of an incense cup. Near these were a portion of a bone-pin, several hand-struck flakes, all of flint, from the neighbouring chalk, a very large tusk of the wild boar, and portions of the upper valve of "Pecten opercularis" which may have been valued as a memento of, at that time, a rather hazardous expedition to the eastern shore-line, as probably the boar's tusk betokened the remembrance of a successful hunting expedition in the then swampy jungle of Holderness. Some dark matter, bits of burnt wood, splinters of bone and teeth of the ox and the pig were lying in places on the floor of the grave, but little trace of human bone was observed, probably the body had become completely decayed.

A little to the south-east of the grave were indications of what proved to be a sloping-sided trench 6½ feet deep, running due south, but owing to the ground being covered with building material we were

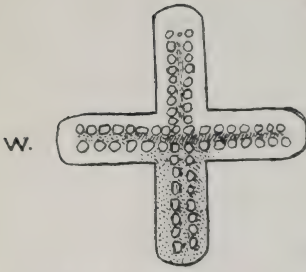


FIG. 8 4.6. in depth

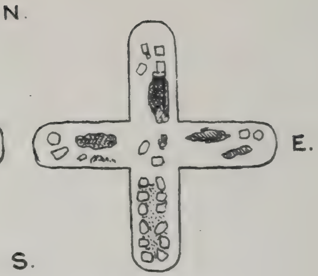
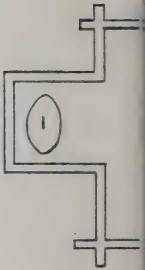


FIG. 9. 9 ft. in depth



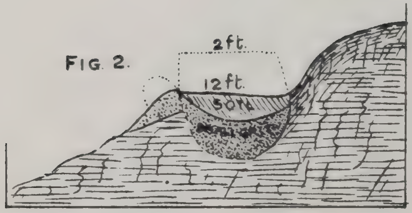
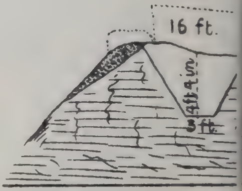
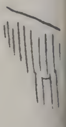


FIG. 2.





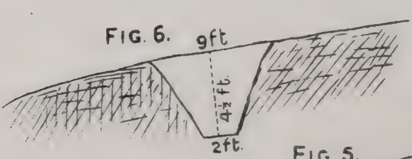


FIG. 6.

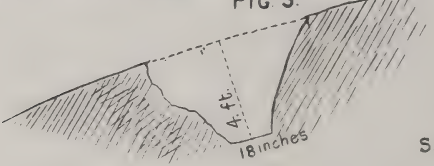


FIG. 5.

SECTIONS OF HOLLOW V

MORTIMER :

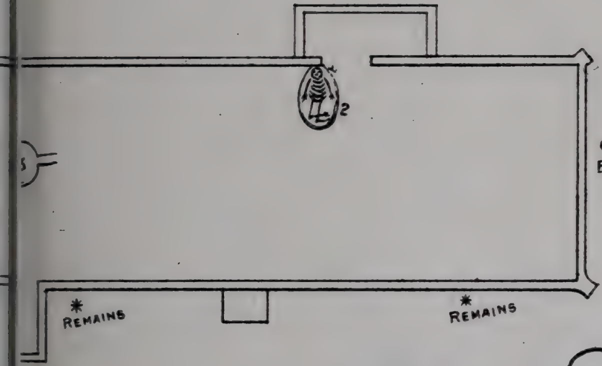


FIG. 10
PLAN OF FIMBER
CHURCH INCLUDING
BRITISH INTERMENTS.

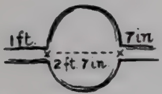


FIG 11. PLAN

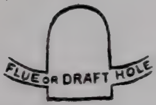


FIG. 12. SECTION.

DOME SHAPED CARVITY

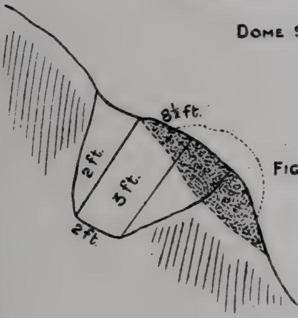


FIG 3.

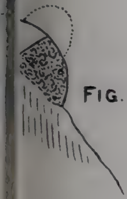
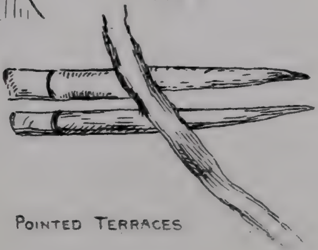
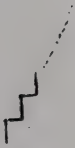


FIG. 1.

FIG 7.





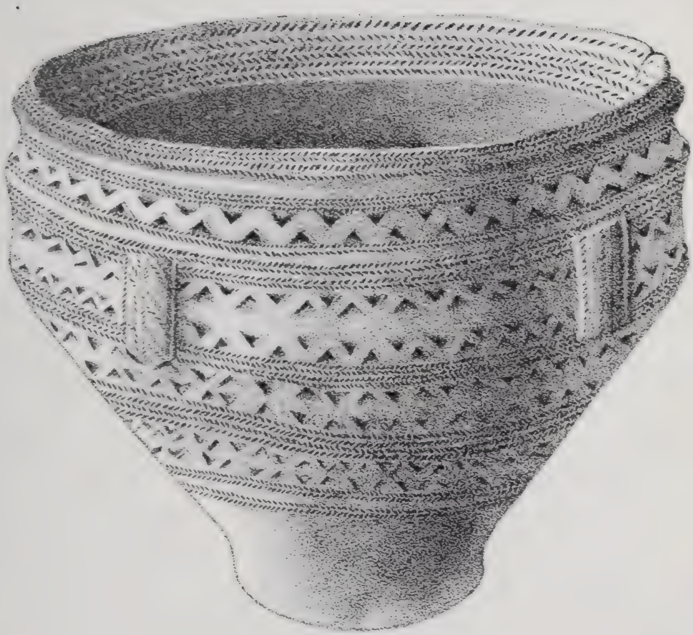
POINTED TERRACES

unable to follow it. In the soil-like matter filling this trench were bits of animal bone, and many teeth of the ox.

On June 29th, the workmen while lowering the ground about one foot, within the foundations of the new church, at a point 45 feet due east of the relics discovered under the old tower, destroyed the body of a full-sized person. On this discovery being made known we examined the ground beneath, and presently found a few burnt bones of a young person, a portion of which the workmen had also removed. In proceeding downwards through the forced earth of the undisturbed portion of the barrow, which here was a little over two feet in thickness, and for the most part of clay from a distance, we picked up many hand-struck pieces of foreign flint. Under the clay came the natural rubbly chalk surface, which to the practised eye seemed to have been entered, and the continued use of the pick soon verified this surmise, by discovering the half of a fine large diamond-shaped arrow-head of black flint, which from its fresh appearance might have been made yesterday. As we proceeded downwards a little clay was observed, mixed in places with the chalk in the grave, and at a depth of three feet into the rock and five feet below the floor of the old church. the bottom of an oval grave was reached, on which rested the body of a medium-sized adult, pl. ix., fig. 10, 2. The head was to the N.W., and the body reposed partly on the back and partly on the right side ; the right arm was doubled by the side, with the hand on the neck and left shoulder ; whilst the left arm was bent at a right angle with hand under the right elbow. The thighs were straight in a line with the body, and the legs below were closely bent back at the knees, with the feet near to, and partly under, the the left side of the pelvis, a very uncommon position. Flat pieces of chalk were piled on the floor of the grave in the form of a trough, and the body lay therein. Under the body, but mostly about the head and shoulders, we observed dark matter. In front of the face stood an elegantly-shaped food vase, pl. x., 5½ inch high, tastefully ornamented, and at the crown of the head were three small hand-struck splinters of flint. The femur measured 17 inches, the tibia 14 inches, and are of rather slender form.

Again, July 22nd, 1870, the workmen in excavating for the erection of a stove in the body of the church, noticed an accumulation of burnt wood and fragments of pottery. The position of these is shown by pl. ix., fig. 10, 3, and were in a line with and about midway between the two previous discoveries. After an examination of that position not disturbed by the workmen, we were able to make out that there had been a dome-shaped cavity, pl ix., figs. 11, 12, (resembling in shape and about twice the size of an old-fashioned beehive) in the base of the barrow existing under the floor of the church, which had not been injured by any previous excavation. The bottom of this mysterious receptacle reached the rubbly chalk surface beneath the clayey earth of the barrow ; and its sides were baked and deeply reddened by the action of intense heat. We also observed remaining portions of two clayey-sided flue-holes, or passages, reaching about 18 inches from opposite sides, a little above the bottom of the dome-shaped structure, in a westerly and an easterly direction. Within each entrance, at a point shown by an *, was what looked like the greatly decayed point of an oak stake. In addition to the burnt wood and fragments of apparently Romano-British pottery it contained, there was a considerable quantity of a vitreous slag-like substance in which were small pieces of what seemed to be fuzed bronze ; and the action of intense heat was everywhere visible within. No trace of bone was observed, but had we been made acquainted with this find previous to its partial destruction, probably something more would have been discovered to elucidate the purpose it had served, which most probably was a crematorium or a sepulchral interment. The writer, however, thinks that only fragments of pottery had been deposited in this receptacle.

These fragments represent three kinds of earthenware, all quite unlike any British pottery known to us, being much superior, better baked, and of a finer and somewhat different texture : and, as previously mentioned, are probably Romano-British. Whatever purpose this somewhat oven-formed structure had served, it seemed quite certain from its intrusive position in the body of the barrow, and the kind of pottery it contained, that its formation was long after the raising of the barrow, but, at the same time, anterior to the building of the first church.



MORTIMER: PRE-HISTORIC FIMBER. ½ nat. Size.

Besides the discoveries made within the foundations of the present church, remains of two other bodies, seemingly Anglo-Saxon, were discovered while excavating for a drain immediately contiguous to the exterior and south side of the church. One was near the east side of the porch, at a depth of two feet, near which was a small Anglo-Saxon bronze buckle ; the other body was about the same depth, and near the east end of the church. Not far from this body, but seemingly unconnected with it, was a curious little article of a metal resembling bronze.

Could a full search have been made in this southern position of the mound most likely more Anglo-Saxon bodies would have been discovered, giving further proof that this British barrow had been, like many others, also used as a cemetery by the Pagan-Saxons previous to the erection of any church upon it. Therefore, at the introduction of Christianity, this ancient mound and Pagan graveyard, then a sacred spot, was chosen as a fitting site for the house of a new faith.

No historical account or discovery is known to the writer to show that a Christian graveyard had ever been connected with the church at Fimber. The present burial ground was licensed in 1877, after which, on December 18th, 1877, the first interment was the remains of John Cooper, an old and respected inhabitant of Fimber, 92 years of age ; and on June 15th, 1883, the writer's mother, Hannah Mortimer, who was born at Fimber, and died in her 88th year, was entombed in the southern edge of this barrow, on which the church stands.

Many barrows in various parts of England are in immediate proximity to a church, but few are known to have been the site of three succeeding churches, and the burial place of four different nations or races of men, viz., ancient British, Romano-British, Anglo-Saxon, and the present English. That an Anglo-Saxon graveyard once existed contiguous to this barrow seems evident, from the fact that on July 25th, 1863, while excavating the foundations for a cottage adjoining the Wesleyan Chapel, and about eighty yards S.E. of the church, the remains of four or more bodies were found. They were not more than two feet from the surface ; and some of them, as far as we could gather from the workmen, had their legs more or less pulled up. They were accompanied with bits of iron and fragments of pottery, most of which were destroyed at the time. A few of the latter are possessed by the writer, and they seem to be Anglo-Saxon. The remains of these bodies were put into a barn, and afterwards examined by the late Dr. Clements of Wetwang, who pronounced them to belong to small persons, chiefly females and juveniles. This discovery produced a considerable amount of excitement at the time among the villagers, and elicited from the late Mr. S. Broadley, the owner of a small plot of ground extending from the Wesleyan chapel towards the church, that he remembered in planting the apple trees in his garden, and at other times when having to dig a little way into the subsoil, that he had frequently found bones.

Flint arrow-heads and Roman coins have, at various times, been found in digging into the ground contiguous to the church barrow. It is also worthy of record that other bodies and weapons have, at various times, been found in places near the village. I remember being greatly impressed, when a boy, by my grandfather bringing home the under jaws belonging to bodies which had been exhumed in quarrying chalk to repair the roads, at a point where the entrenchments are cut by the road to Sledmere, about 500 yards eastwards from Fimber Station ; and an old labourer, named Lockwood, who was for many years servant with my grandfather, remembered human bones, and what he described as an iron sword, having been found many years since, where the road to Malton cuts the same entrenchments about 300 yards northwards from Fimber Station ; whilst nearly half a mile to the S.S.E. of Fimber Station, by the side of the road from Malton to Beverley, which is on the site of the Roman road between these two places, and where this road is crossed by a green lane, which, we believe, is also the site of a Roman road from York to Bridlington and on to Flamborough, we, during 1873 and 1874, explored a portion of a Romano-British graveyard, a description of which I may give at some future time as a supplement to this paper.

ON THE LARGER BOULDERS OF FLAMBOROUGH HEAD. PARTS II. AND III.

BY G. W. LAMPLUGH.

The object of this paper is to give an enumeration of the boulders in the Danes Dyke Valley, and on the shore eastward to South Sea Landing; with a discussion of their origin, and a comparison of them with those found near Withernsea.

In pursuance of an investigation into the nature of the larger boulders of Flamborough Head, commenced two years ago, I have examined and catalogued those which lie in the ravine of Danes Dyke, and also those on the shore between Danes Dyke and South Sea Landing. The former list becomes Part II. of the series; the the latter, Part III.

PART II. THE DANES DYKE RAVINE.

The cliff sections at Danes Dyke show that at this part of the headland there existed in pre-glacial times a deep valley in the chalk, which was afterwards filled in and obliterated by the accumulations of the glacial period. It has since, however, been partly re-excavated by a small stream, arising from the surface drainage, which, though it runs only in winter and stormy weather, has sufficed to cut its way down through the easy-removable infilling of clays and gravels, to the old chalk-floor. The current of this stream is only strong enough to carry the lighter stones, so that a residuum of larger blocks has accumulated in its bed, and lie there perishing slowly under the weather.

I have examined these boulders, and, after rejecting all whose greatest diameter does not exceed one foot, found 142 erratics between the mouth of the valley and the Flamborough and Bridlington high road where the valley practically terminates. Doubtless many more lay hidden under the gravel which in places cumbers the stream-bed, but these were all that were visible at the time of my survey.

The chief importance of the list is that there is in this case no probability of the boulders having been much disturbed by man, as the banks of the ravine are generally steep and inaccessible; and we may, therefore, find in it a test for the trustworthiness of the lists compiled upon the shore.

The classification of these boulders yields the following result :—

2. BOULDERS IN THE DANES DYKE VALLEY.

		Per centum.
25	Limestones, undoubtedly of Carboniferous age ...	17·6
5	Sandstones, undoubtedly of Carboniferous age ...	3·5
7	Limestones, origin unproved, but either Magnesian or Carboniferous	5·0
31	Sandstones and Grits, origin unproved, but suspected to be Carboniferous	21·8
2	Pebbly quartzite and conglomerate : undoubtedly Primary rocks	1·4
1	Limestone derived from the Lias	0·7
62	Basaltic rocks	43·7
2	Fragmental volcanic rocks	1·4
2	Schistose and Metamorphic rocks	1·4
5	Granitic rocks	3·5
142		100·0

Before discussing these results, I will give the details of the third part of my paper.

PART III. THE SHORE BETWEEN DANES DYKE AND THE FLAMBOROUGH SOUTH SEA LANDING.

In this case the list is a direct continuation of that given in Part I., and nearly all the boulders observed lay upon the shore between high and low water-marks, whither they have fallen through the erosion of the thick capping of drift which overlies the cliffs of chalk. The cartmen have commenced their raids upon them, and will in time remove all that are movable.

My list contains 110 Boulders, consisting of the following rocks :—

3. BOULDERS BETWEEN DANES DYKE AND SOUTH SEA LANDING.

		per cent.
20	Limestones, undoubtedly of Carboniferous age ...	18·2
8	Sandstones and Grits, undoubtedly of Carboniferous age	7·3

		Per cent.
3	Limestones, origin unproved, but two are probably Carboniferous, and the remaining one may be Silurian	2·7
25	Sandstones and Grits, origin unproved, but all excepting one are suspected to be Carboniferous. The exception may be Jurassic	22·7
6	Quartzite, conglomerates, etc., undoubtedly Primary	5·5
41	Basaltic rocks	37·3
4	Gneissic, schistose and metamorphic rocks ...	3·6
3	Granitic rocks	2·7
110		100·0

Notes.—When compared with each other and with the list given in Part I., they are found to be quite consistent, and may, I think, be taken as yielding reliable indications of the proportion of the various rocks which form the larger boulders contained in the drifts in this locality. The only important variation is in the percentage of sandstones, which is higher on the shore than in Danes Dyke Valley, while that of the basaltic rocks is decidedly lower; especially in the first list, and this may be very readily explained by the action of the cartmen, who select the harder rocks for "road metal" but reject the sandstones.

The most striking feature of the lists is the great preponderance of rocks from the Carboniferous and the all but total absence of Jurassic boulders of the requisite size. Thus out of the 328 erratics which the three lists contain not more than *one* can be identified with positive certainty as Jurassic.

It must be remembered however that this refers only to the *larger* boulders, for a casual inspection of the smaller stones would almost everywhere reveal many Secondary pebbles. But, in my belief, it is to the larger, and especially to the angular and subangular blocks, that we should look for evidence as to the actual origin of the ice, for the smaller pebbles may never have been fixed in the mass of the ice at all, but may be merely beach-pebbles which the ice-sheet has worked into its basal-moraine as it passed along over the sea-bed. In numerous instances we have direct proof that pebbles have undergone marine erosion previous to their glaciation.

It is of course possible that some of the undetermined sandstones may have come from the Oolites, but this, as I showed in my first paper, is not probable when we consider the large number of recognizable carboniferous rocks, and compare it with the paucity of recognizable secondaries.

This overwhelming preponderance of carboniferous and older rocks on Flamborough Head is more or less a local peculiarity due, as I believe, chiefly to the height and steepness of the unbroken line of cliffs on the northern face, which, existing in pre-glacial times, much as at present, deflected the lower layers of the ice-sheet, and allowed only the higher portion to pass over the cliff. This view has been strongly impressed upon me by the detailed examination which I have recently made of the drifts of the whole headland, but it is beyond the scope of this present paper to discuss the matter further.

With the object of proving among other things whether local differences in the distribution of the boulders could be detected by the means adopted, I selected a spot on the Holderness coast near Tunstall, between Hornsea and Withernsea, about thirty miles south of Flamborough, where erratics had accumulated in great numbers on the shore, and there, without specially particularizing them, I counted and examined 500 boulders which lay within a given area, all over one foot in diameter, and obtained the following results :—

4. BOULDERS AT TUNSTALL NEAR WITHERNSEA.

		Per centum.
114	Limestones, undoubtedly Carboniferous ...	22·8
78	Sandstones and Grits, probably all, or nearly all Carboniferous	15·6
78	Limestones, undoubtedly Jurassic, chiefly from the Middle and Lower Lias	15·6
25	Septarian Clay-limestone nodules, probably all from Secondary clays, chiefly Kimeridge ...	5·0
7	White Chalk	1·4

		Per centum.
4	Qartzite and conglomerates, undoubtedly Primary	0·8
187	Basaltic rocks	37·4
3	Gneissic and schistose rocks	0·6
4	Granitic rocks	0·8
500		100·

By combining the three Flamborough Head lists we obtain a total of 328 Boulders, which furnish sufficient grounds for comparison with the 500 from Tunstall. The following table contains the condensed results of this comparison, and reveals an interesting difference in the character of the two lists :—

5. COMPARATIVE TABLE.

	Flamborough Head. Per cent	Tunstall. Per cent.
Carboniferous Limestones, including the "doubtful" blocks	20·0	22·8
Sandstones and Grits, supposed to be Carboniferous	39·0	14·4
Secondary Rocks	0·3	22·1
Basaltic and other Eruptive rocks ...	34·0	37·4
Gneiss, schist, granite, etc.... ...	6·7	3·4
	100·0	100·0

This table shows at a glance that the Holderness boulders, while essentially agreeing with those of Flamborough, differ from them in the presence of a considerable proportion of secondary rocks. The fact that the former locality lies further within the area covered by Secondary strata has no doubt something to do with this difference, but is not in itself a sufficient explanation, since there is no known border to the rocks of this age at a less distance than sixty miles from Flamborough Head, a distance surely more than sufficient for the Secondary erratics to establish themselves. I think that the main cause of the difference is as already indicated, that the lower layers of the ice which carried the secondaries were deflected eastward and southward by the high cliffs of the headland. Further researches now being carried on will no doubt elucidate this point.

Lest it should be thought that I have entered upon these generalizations at too early a stage of the investigation, and without sufficient basis, I may add that a preliminary survey of the boulders which will go to form my future lists, especially of the very large number which lie upon the shore a little to the southward of the Lighthouse, has shown me that I shall not find any radical or important change in the nature of the rocks yet to be collated.

In the appendix will be found detailed notes of those boulders which merit especial attention because of their composition or their large size. The less important ones it is unnecessary to particularize. It must be remembered however that as my knowledge of igneous rocks is very imperfect, the terms I have used in describing such rocks are to be received with caution.

APPENDIX TO PART II.

THE MORE IMPORTANT BOULDERS IN DANES DYKE VALLEY.

The prefixed number indicates the ordinal position of the boulder in the original full list. The sign + placed after a measurement shows that it has been impossible to determine the full size of the block. All dimensions in inches.

No.

10. *Position:* In the stream-bed above the lowest bend. *Description:* Light-coloured close-grained gritty limestone with indeterminable fossils. *Age:* Probably Carboniferous. *Size and shape:* Irregular cube. 26 × 19 × 13 inches.

14. A few yards above 10, in the stream bed: Brecciated limestone with encrinites, much weathered. Carboniferous. Irregular cube. 40 × 34 × 25 inches.

22. In the stream-bed above 14. Limestone with encrinites. Carboniferous. Rude rhomb. 34 × 19 × 12.

46. Twenty yards below the bridge. Mica-schist with quartz. 13 × 12 × 6.

47. Near 46. Coarsely-crystalline red granite (*not* Shap.) 12 × 10 × 9 +.

52. In the stream-bed above the bridge. Dark fine-grained Basalt. Flat glaciated surface alone visible. 24 ×, 19 +

69. Beyond the next bend. Coarse-grained Basaltic rock. Rudely oval, with blunted angles. 31 × 18 × 21 ×.

79. Above 69 in the stream-bed. Fine whitish sandstone: Age unknown. Rhomboid. 29 × 21 × 15.

94. In the stream-bed below the tributary. Hard porphyritic rock with acicular crystals, purple with a pinkish surface. Felstone? Rounded oblong. 16 × 9 × 9.

95. Close to 94. Coarse dark Basalt. Angular cube with worn faces. 24 × 21 × 15.

112. In the bank, about 100 yards below the high road. Volcanic breccia of striking appearance; angular fragments enclosed in a deep blue matrix. Rude spheroid. Just under 12 inches in diameter.

131. Nearer the road. Pale greyish granite rock. Flat and well glaciated. 13 × 10 × 6.

136. Near 131, in the left bank. Dark red sandstone, with obscure fossils, probably encrinites. Carboniferous? Oblong. 27 × 19 × 9.

141. In the water-pool near the road. Fine-veined mass of greenish-grey grit or conglomerate, with pebbles; appears slightly metamorphosed. Primary.

NOTE.—A few claystone nodules and fragments of Lias-limestone were observed, but with one exception these were all under the one-foot limit. There were also a few pebbles of flint, which are noteworthy, as the chalk in the immediate neighbourhood has no flint.

APPENDIX TO PART III.

THE MORE IMPORTANT BOULDERS BETWEEN DANES DYKE AND SOUTH SEA LANDING.

No.

2. Opposite Danes Dyke, at half-tide. Crystalline Limestone with obscure fossils. Carboniferous. Irregularly oblong. 48 inches × 25 × 18 +.

3. A little further east, nearer the cliff. Fine-grained pale-yellow sandstone, origin unknown. Rhomboid with worn angles. 26 × 25 × 20. (Several others, nearly as large, of the same rock, between Danes Dyke and the first headland. Nos. 5 to 14).

15. Near the cliff, slightly westward of Hartendale Gutter. Peculiar fine-grained soft slaty-green claystone (?) with small crystals of pyrites, interlaced with quartz-veins. Primary, probably Silurian. Rude oval. 36 × 34 × 24 +.

17. Beyond Hartendale. Soft reddish sandstone with fossils. Carboniferous. 15 × 13 × 9.

NOTE.—I was inclined to regard this block as oolitic, till by breaking it I found casts of *Spirifera* and encrinital stems. This has happened to me so often in examining these sandstones (which are frequently calciferous) that I have come to look upon the whole as Carboniferous.

19. Between Hartendale and Beacon Hill, close to cliff. Peculiar pale-red speckled calciferous sedimentary rock, with appearances like fossils. Silurian? Rhomboidal. 20 × 17 × 12 +.

28. Under west side of Beacon Hill, eight yards from the cliff. A grand pear-shaped mass of grey granite, coarsely but confusedly crystalline. Well-rounded. 64 inches × 40 × 24.

41. Beyond Beacon Hill, rather above half-tide level. Pinkish gritty limestone with fossils. Carboniferous. Rude spheroid. 52 × 40 × 36.

42. Near 41. Dark coarsely-crystalline Basaltic rock (Diorite?) Irregular spheroid. 24 × 19 × 17.

44. Near 41. Greenish gneiss with quartz-veins. Oval; worn. 40 × 25 × 20.

47. Near West Nook. Hard close-grained bedded crystalline rock (quartzite?) Rhomboidal. 31 × 24 × 22 +.

51. *(Starting afresh from Danes Dyke at low-water).* Below half-tide near Danes Dyke. Dark quartzite? Rudely-oval. 50 × 36 × 30.

56. Below half-tide, just beyond Hartendale. Close-grained black Basalt. Oblong. 54 × 30 × 33.

61. At half-tide, opposite Beacon Hill. Coarse-grained greenish-black Basaltic rock (Diorite?) with glassy crystals. Rectangular, with flat sides. 36 × 33 × 23.

70. At low-water off West Nook. Greenish amygdaloidal Basalt. Flattened disc. 26 × 24 × 11.

88. Off Hartendale at dead low-water. Stratified sandy limestone. Probably Carboniferous. Oblong, sub-angular. 65 × 26 × 38.

NOTE.—Many large blocks may be seen in this neighbourhood when the tide is very low.

98. Near 88. Coarsely-crystalline greenish rock. Diorite? Pear-shaped. 50 × 20 × 18.

103. At dead low-water further west. Soft sandy limestone. Probably Carboniferous. Oblong. 70 × 36 × 22.

SOME NOTES ON GOLD, SLATE, AND SALT MINES IN GREAT BRITAIN.

BY ARNOLD LUPTON, F.G.S., M.I.C.E., PROFESSOR OF MINING ENGINEERING AT THE YORKSHIRE COLLEGE.

Coal-mining is undoubtedly the most important branch of mining industry at the present date. This was not always the case. The Book of Job contains some account of mining which includes no reference to coal-mining. Indeed, so far as the evidence goes, coal-mining is comparatively modern, and it is only within the last 500 years that any need of the use of coal in large quantities has arisen. Wood supplied all the fuel necessary until the growth of the large city of London and the increase of Ironworks; and doubtless the extension of grazing and agriculture in England rendered wood comparatively scarce, and induced a resort to the mineral fuel which is now generally preferred to wood, even in places where timber is still plentiful. Almost every other kind of mining is ancient. Copper and tin were mined in earliest ages, of which we have written or engraved history, and probably long prior to the historical period. Iron was also mined, though, it is believed, not till a later date than copper and tin. Gold and silver mining is also antecedent to the earliest records.

Great Britain is endowed with a store of mineral wealth, which embraces nearly all the metals and minerals for which the earth is searched. Some notable exceptions there are. Quicksilver, platinum, diamonds and other precious stones and petroleum are not to be found, but there is gold, silver, lead, tin, copper, zinc, nickel, manganese, antimony, arsenic, iron, and many others. The non-metallic minerals also abound, fire-clay, china-clay, freestones, slates, salt, sulphur, in the form of sulphides of iron, copper and lead; coal, cannel, jet, fluor-spar, gypsum, marble, limestones, and many other minerals are ready for our use. Of course it is not profitable to mine any metal in one country if it can be got at less cost from another, unless legal restrictions interfere with the free course of trade. With the exception of certain periods and certain articles of commerce in these periods, England has been, on the whole, a free-trading country, and it was one of the chief articles in the instrument known as Magna Charta that there should be no interference with trade by the sovereign. There is no country (so far as I have ever read or heard) which has placed restrictions upon the importation of gold, though, exactly, why gold should be admitted free, whilst iron and corn or copper and lead were taxed, it is not easy to understand. Gold has many uses, such as coinage, stoppings for decayed teeth and ornamentation, but it would hardly be missed if it was never seen in comparison with the loss that would ensue from the loss of iron, copper, tin, lead, &c. Whatever the reason may be gold has been always freely imported, and hence the gold mines of Great Britain (and Ireland) have been neglected, whilst our supplies of this most beautiful and lovely metal have been drawn from countries which had either more abundant stores of it, or less of other mineral wealth or manufacturing industries to engage their labour. The most ancient and easy manner of obtaining gold is to wash the sand in ancient river beds that contain grains of gold. The more modern method is to crush the rock in which gold exists. Where gold is got by mining it is chiefly, though by no means exclusively, found in quartz veins, where it exists in tiny grains of pure gold. To separate it from the quartz it is necessary to crush the rock into sand, after which the gold grains may be separated from the sand. This process of obtaining gold is more difficult than the simple gold-washing process. Firstly, the mine is required and the use of explosives to break up the exceedingly hard rock, then the costly machinery driven by water-power or steam-power for pulverizing the rock.

The chief supplies of gold now come from the river-washings and from mines in quartz reefs in Australia, Siberia, the Rocky Moun-

Fig. 1.

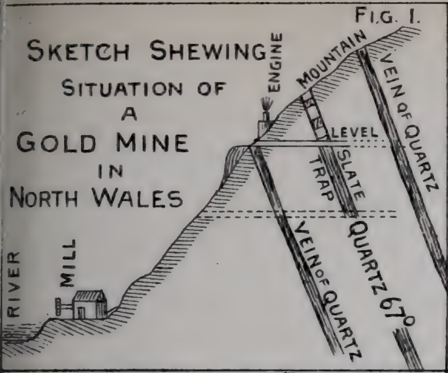


Fig. 2,

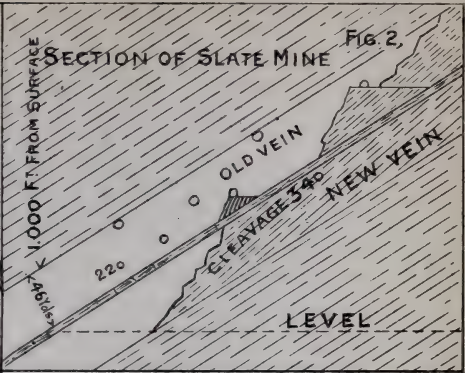


Fig. 3.

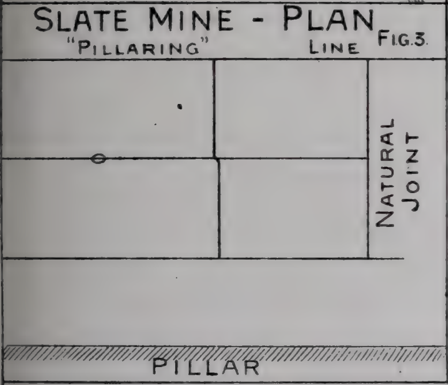


Fig. 4.

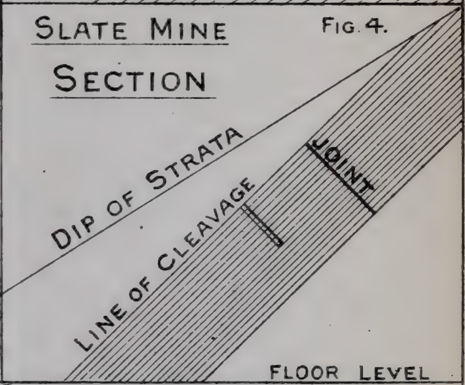


Fig. 5.

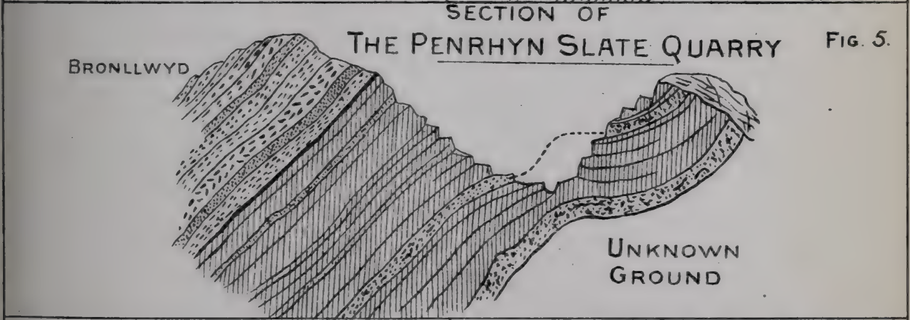


Fig. 6.

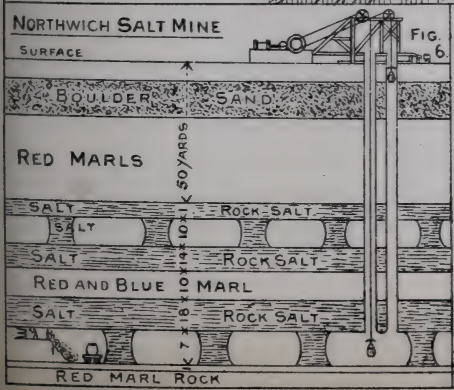
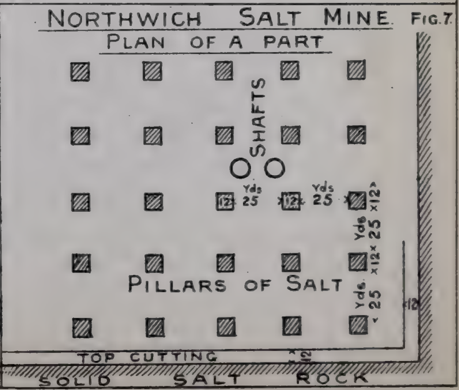


Fig. 7



Lupton: Gold, Slate, and Salt Mines.

tains, Venezuela, and India, though there are other formations, such as the Mount Morgan crater in Queensland and the Transvaal conglomerates, producing extraordinary quantities of gold.

It will be at once understood that the success of the operation of mining and crushing quartz depends to a great extent on the use of machinery.

With rock drills, driven by compressed air, high explosives, steel-headed stamps, driven by water or steam power, the cost per ton of quartz may be reduced from an excessively high figure such as it must have been in ancient days to a very moderate price, say, 8s. a ton, as may be to-day in a modern mine.

There is no country in the world where mining can be done more cheaply than in Great Britain ; machinery and labour are both cheap and efficient ; water-power is often available in the mountains, and coal is everywhere cheap. Therefore for the working of a gold-mine it is only necessary to ensure success that there should be a moderate amount of gold.

In Australia a mine will pay well if there is an average of 5 dwts. of gold per ton ; if we say a dwt. is worth 3s. 4d. this will give a value of 16s. 8d. a ton to the quartz ; if this will pay in Australia a smaller percentage of gold will pay in England or Wales.

A good deal of excitement and a little speculation has recently resulted from the opening of a gold mine by Mr. Pritchard Morgan in Wales. It has always been known that gold existed in Wales, and gold was got there in ancient days both before and during the time of the Romans, and since then at various periods ; and during the last 30 years some mines have been worked with varying success. One mine has produced £40,000 worth of gold in all during a period of 18 years. In the district near Dolgelly gold has been worked, and the mines are known to some intelligent miners.

Since Mr. Morgan took it up, a level has been driven into the hill-side to cut a quartz vein, and is being driven forward to cut other veins. (Pl. xi. fig. 1). In the first vein a level has been driven, and a small working opened in the vein. (September, 1888). The vein has here a width of 20 feet ; it dips north at an angle of about 67°; the "hanging wall" is slate rock and the "foot wall" is trap rock ; near to the foot wall the vein contains iron ore, iron pyrites, blende, and some other metals, and also grains of gold ; in some places the gold is visible in the iron ore, in others tiny specks may be seen in the quartz ; in the place where most of the ore is got they are getting a width of 10 feet ; some of the ore is very rich, containing at the rate of several hundred ounces of gold per ton ; the whole is said to contain on the average two to three ounces of gold per ton; the greater portion is said to contain 12 dwts., or say, 40s. worth of gold per ton. It will be evident that if the mine continues to produce quartz of this quality that it will reimburse the capitalists for the outlay they have made.

But of course it must be expected that the vein will vary in width and richness. The mine is situated in a mountain side several hundred feet above a river, and a steam-engine is used to work an inclined tramway to the mine ; another steam-engine is being erected to work one of Sturgeon's air-compressors intended to drive Ingersoll Rock Drills. In September, 1888, about 40 miners were employed. The quartz is taken to the stamps which are situated by the river at a waterfall, which works a 40 feet wheel, three sets of stamps, five heads in each ; these stamps will crush about 30 tons of quartz in 24 hours. All the rock has to be crushed until it will pass through a wire guage of thirty meshes to the inch, which is rather finer than a safety lamp gauze ; a stream of water passes through the stamps and carries the sand through the gauze over copper plates which have been covered with quicksilver ; quicksilver has the property of amalgamating with gold, so that the gold is caught whilst the sand is washed away.

When the copper plates have received a sufficient coating of auriferous amalgam it is rubbed off, and the amalgam is squeezed in bags to drain out the uncombined mercury ; the gold amalgam is then put into a cast-iron retort and heated till all the mercury has been evaporated, and the mercury is saved by passing through a condenser and used over again ; the gold, which remains in a spongy state, is melted in a plumbago crucible and cast into an iron ingot mould.

At the Morgan mine I was informed that 95 per cent. of the gold in the quartz was obtained, the remaining 5 per cent. being lost. Such a result is very good. It is not the intention to express any opinion as to the future prospects of any particular mine, but it may be pointed out that the rules that govern success are simple, and are as follows :—

1st. The vein must contain on the average a sufficient quantity of gold to repay the cost of working, including interest on the necessary capital. The necessary capital, it must be remembered, does not include the large sums sometimes paid in purchase of future profits.

2nd. When a rich pocket is worked a good share of the profits should be set aside and applied to the development of the mine, otherwise the enterprise will collapse as soon as unprofitable ground is encountered, which is sure to happen sooner or later.

3rd. The best machinery must be employed, and a sufficiently large out-put of quartz rock maintained to reduce to the minimum the cost per ton of the necessary fixed expenses.

4th. Expensive London offices must be dispensed with, and salaries only paid for competent direction on the spot. If these conditions are rigidly observed, the mine will pay well if the vein contains on the average 5 dwts. of gold per ton.

In ancient days the value of gold was many times its present price. Five hundred years ago, in England, gold was worth seven times its present price, and therefore other things being equal, a gold mine would then be very profitable which would now be ruinous ; but other things are not equal, the invention of dynamite, of compressed air rock-drills, of improved stamps for crushing the rocks, of improved concentrators, the greater security of the capitalist in the present stable order of society, and perhaps a lower rate of wages, all tend to counteract the present cheapness of gold as compared with five hundred years ago.

The method of mining for gold as found in quartz veins is similar to that used for other minerals found at a steep angle, and is a kind of pillar and stall. First the vein is cut by a cross measure drift, next levels are driven in the vein, and cross-cuts are driven up and down, afterwards the pillars of better quality are worked out, leaving supports for the main roads and shafts.

The gold of North Wales is found in veins traversing the slate rocks of the Lower Silurian system, and parallel to intrusive beds or veins of trap or greenstone.

These same beds of Silurian slate are found ten miles to the northward, and are traversed by similar veins of greenstone, and here at Ffestiniog it is not the intrusive vein that is valuable but the slate rock itself, which is capable of being split up into most valuable and perfect slates. The most valuable bed of slate, called the "Old Vein," lies at an angle of 23° and dips under a mountain, where it is mined on the Pillar and Stall system. In one of these slate mines there are twenty miles of underground roads. The roof is standing on the pillars all over, and no attempt has been made to remove the pillars, nor will be made for generations yet to come, if ever. In this respect a slate mine differs from an ordinary coal mine, where the pillars are worked out soon after they have been formed.

The slate vein (it is called a vein, though it is really a stratified rock) is reached by levels driven into the mountain side and by an inclined road. up which the slate trucks are drawn from the lowest part of the mine by a steam-engine. Right and left of the incline levels are driven in the slate ; the levels are about twenty yards apart in a vertical line.

The vein is 46 yards thick ; the levels are driven about seven feet high, in the top of the vein ; the roof is marked by a parting of white clay, called a clay slant. The levels are connected by cross-heads every twenty-three yards ; these cross-heads are all in the same straight line from rise to dip, and make a series of parallel inclines. The cross-heads are widened out from the level to a width of 45 feet, leaving pillars 24 feet wide ; the stalls or breasts are worked from the level towards the rise, the clay slant forming the roof ; the floor of the working place is carried level till it reaches the base of the vein (fig. 2). As a breast is carried up from a lower level it cuts away the rock forming the level above, and therefore if the upper level is to be maintained as a road it is necessary to put a timber bridge over the working, or else move the level more to the "rise," which can easily be done by driving through the pillars.

When beginning a breast it is easy to examine the roof, but as the breast advances it is not easy to repeat the examination of a roof 10, 20, 30, or 40 yards over-head. The slate-rock, however, is very sound and safe, and it very rarely happens that any pieces fall. One manager has contrived an apparatus for sounding the roof, consisting of a small hammer, fixed on a pin at the end of a long pole or gas-pipe, and by means of a rod the hammer is made to hit the roof and so test its security by the sound. The mines are lighted with candles, which are the best kind of light yet invented for the use of the rock men and miners, as they can be placed exactly where required.

The slate is got by blasting and wedging. It must be understood that to get slate as in getting any other solid substance it is necessary to have three lines of fracture before a single piece can be separated from the mass.

In getting a lump of coal the three lines of fracture are :

(1) The line of stratification where the coal joins the roof.

(2) The line artificially made by cutting through the fast end.

(3) The line of cleavage called the face.

By these three lines of fracture, rectangular blocks of coal are got.

In a slate mine all three lines of fracture are natural, and separation takes place upon the application of pressure. These lines are as follows : figs. 3 and 4.

(1) The cleavage or split of the slate. At Ffestiniog the plane of cleavage dips at an angle of about 12° towards the plane of stratification.

(2) The "pillaring" fracture which is a plane of cleavage vertical to the split, but in the same direction.

(3) The joints which are irregular planes of natural fractures traversing the slate rocks at right angles to, and vertical to, the plane of cleavage.

In working the slate the sides of the breasts or pillars are made parallel to the plane of "pillaring" fracture. A loose end once made, fresh blocks of slate are separated by blasting ; the drill-hole is about vertical to the cleavage, and causes the slate to crack along the pillaring line through the centre of the drill-hole, the length of this fracture being from joint to joint, and the depth equal to the depth of the hole. The drill-hole is about one inch diameter, and is nearly filled with black gunpowder, in appearance something like sporting gunpowder ; a very little tamping is lightly rammed on the top. The effect of filling the hole with powder is to produce a simultaneous pressure from top to bottom, and the effect of gentle tamping is to diminish the violence of the explosion. Hard tamping would cause a violent explosion that would destroy the slate.

In some mines a lower bed of slate is worked under the "Old vein." This is separated by a layer of silicious rock, called chert, about two yards thick ; this chert is the floor of the "old" vein and the roof of the "new" vein ; the vein is about 26 yards thick, and the pillars are left in it exactly below the pillars in the old vein.

It has happened in at least one large mine that the pillars have been left too small, with the result that they have suddenly fallen and all the ground above, letting down millions of tons of rock, and doing great injury to the mine. This incident of course has many parallels in the annals of coal-mining. Up to the present time slate mining has been of far more importance to Wales than gold-mining ; the annual value of the slates produced at the mines and quarries of Wales exceeds one million sterling.

When the slate is sent to the surface it is cut and split into lumps of convenient sise, and then it is put on a saw-bench and cut by a circular saw so as to give it a smooth end, when a chisel can be introduced to split it ; the splitting is all done by hand with a chisel and hammer ; the slates when split are cut by a revolving knife to the correct size and shape. The slates must be split as soon as they reach the bank, because if allowed time to dry they are not easily split. One of the most remarkable conditions of slate-mining is the immense proportion of waste material ; it is common to find that out 100 tons of slate rock only five to ten tons are actually made into slates, the rest is all tipped into the waste heap. This is the reason of the costly nature of slate-mining, because the cost of getting one ton has to be multiplied by twelve in order to find the cost of the slates sent to market ; the mine or quarry has to be twelve times as large as the space required for the finished slates; and enormous waste heaps must be formed, and locomotives provided, to carry the waste to the tip. In this respect a slate-mine resembles more a Low Moor ironstone mine than a coal-mine. Many of the most extensive slate quarries are worked as open holes, fig. 5, consequently no pillars are required. An attempt is now being made to utilize some of the slate waste by crushing it to powder, and forming it into tiles and other kind of earthenware.

Slate-quarrying is sometimes very profitable, and enormous fortunes have been made in this business ; but competition has cut down prices, so that the owners of the best quarries have to be content with moderate gains, whilst the quarryman gains by increased employment, and the public by greater cheapness of a very useful article. When the competition of producers has at last reduced the price of any article to a minimum, it generally occurs to those engaged in the trade to endeavour to secure an increase of price by limiting the production ; an example of such an endeavour has been given to us in the salt trade. All the producers of salt in the country have combined to raise the price and limit the production, a line of conduct well within their legal and moral rights, but with their success in this combination we shall not rejoice, nor shall we sorrow with their failure. Nature, who has lavished on this island her choicest gifts, in a variety and abundance perhaps unparalleled elsewhere upon this earth, has endowed us with immense stores of rock salt, a mineral of the utmost value, and essential not only as an article of diet but to our immense chemical works.

The old-established sources of production at Northwich and Droitwich have recently been supplemented by discoveries of salt on the banks of the Tees ; these discoveries have benefited the makers of alkali, but have tended to lower the price of salt.

Salt at Northwich is found in a bed lying nearly horizontal, interstratified with red and blue marls of the Keuper series. It is reached at a depth of 50 yards, and the bottom of the salt is 110 yards from the surface ; in the middle is ten yards of shale, fig. 6. The top ten yards used to be worked, leaving pillars ten yards high to support the roof, but these workings have been discontinued ; the old hollows are filled with water, which becomes brine by dissolving the salt ; this brine is pumped up and evaporated in great pans, two tons of salt being produced by burning one ton of coal. By continually pumping the brine the salt pillars have been dissolved, and the roof of the mine has fallen down ten yards, and great holes have been made in the surface ; in Northwich the subsidence of the surface has caused many picturesque arrangements of an architectural kind, and in some of the houses the varying inclination of floors makes the visitor think he is at sea. All the new houses are now built with wooden frames filled in with brick. The inhabitants who depend for their living on the salt industry do not make much fuss about the subsidence of the surface here and there, for, paradoxical as it may sound, it is strictly true that their commercial prosperity is *founded* upon the abstraction of their *foundations.*

Rock salt is now got from the lowest eight yards of the salt beds, which is the purest ; the shafts are 110 yards deep. The salt is got in one mine (the Marston mine) over an area of 40 acres, the roof being supported by pillars 12 yards square and 25 yards apart, thus the pillars left are only one-tenth of the total area, (fig. 7.) And yet the whole 40 acres rests upon these pillars without any sign of cracking, proving at once the hardness of the roof and floor and of the pillars, every square inch of which must bear a pressure of 3,000 lbs. It may, I think, be said that there is no example of a coal-mine standing open on pillars, which are only equal to one-tenth of the total area.

The salt is got by cutting a leading stall or breast about 7 feet high next the roof ; the floor is then got by blasting as required; the 7 feet wall is got by holing or under-cutting, and blasting it down ; the blasting is done with gunpowder, and straws filled with powder for fuses : the holing is done with a pick ; but in one mine, at least, it is done by cutting-machines driven by compressed-air, which cut a nick 2 feet 6 inches under the salt. One of these machines will hole twenty-five yards in a shift of eight hours ; there are three machines in this mine. When compressed-air machines are used there is ventilation caused by the exhaust air ; where there are no machines there is no method of ventilation. There are two shafts, one upcast and one downcast, but there is no separation between them, and they are close together. It is surprising that with blasting going on all day that the mine should be pleasant and seem clear. In some mines the shafts are only 4 feet in diameter; the salt is drawn in round barrels. The red marls are overlaid with boulder clay and sand, and the shafts are tubbed with iron-tubes through the sand. The salt mines are perfectly dry.

To describe the process of preparing rock salt for the market and evaporating brine would unduly lengthen this paper; and therefore, in conclusion, attention is called to the statistics of minerals taken from the government returns given in the appendix. The minerals therein-named are found abounding in this country, in scenes which but for them would be the untroubled domain of the shepherd and the ploughman; they are treasures that for countless ages have been hidden, held fast within the earth and trebly locked; for nature's locks cannot be picked, they yield indeed only to three keys, which have been named industry, knowledge, and enterprise; with these (like the "open sesame" of the fairy tale) the subterranean gates fly open, and through those portals we can pass, indeed have passed, like Proserpine, or like the hero of Arabian Tales, and reach to wealth, and in the products of that wealth to active enjoyment and knowledge of the world, exceeding by far all the records of history, and casting into greater obscurity alike the fabled palace of Plutus and the caves of an Eastern fancy.

APPENDIX.

MINERAL PRODUCE OF THE UNITED KINGDOM, 1887.

	Weight Tons.	Value £
Alum, Clay (Bauxite)	4,169	1,040
Alum, Shale	2,586	323
Arsenic	4.618	32,458
Arsenical Pyrites	4,364	3,205
Barytes	24,813	26,619
Bog Iron Ore	9,273	4,636
Clays (excepting ordinary clay)	2,413,693	590,412
Coal	162,119,812	39,092,830
Cobalt and Nickel Ore	154	900
Copper Ore	9,079	20,982
Copper Precipitate	280	3,075
Fluor Spar	283	385
Gold Ore	cwt. 17⅔	209
Gypsum	120,783	48,293
Iron Ore	13,098,041	3,235,355

MINERAL PRODUCE OF THE UNITED KINGDOM, 1887.—*Continued.*

	Weight Tons.	Value £
Iron Pyrites	22,079	12,682
Jet	lbs. 1,448	289
Lead Ore	51,563	429,137
Lignite	1,764	793
Manganese Ore	13,777	11,110
Ochre, Umber, &c.	8,293	15,789
Oil, Shale	1,411,378	355,085
Petroleum	66	99
Phosphate of Lime	9,894	15,830
Salt (180,000 tons of Rock Salt) ...	2,193 951	732,320
Slates and Slabs	464,334	1,118,818
Stone, &c.	24,000,000*	8,609,600
Sulphur of Strontia	15,169	7,584
Tin Ore	14,189	878,831
Tungstate of Soda	1	24
Wolfram	54	1.269
Zinc Ore	25,445	76,182
Total value ...	206,043,905	55,326,164

* Tonnage estimated by author.

FURTHER NOTES ON THE POLYZOA OF THE LOWER GREENSAND, AND THE UPPER GREENSAND OF CAMBRIDGE. PART II.[*]

BY GEORGE ROBERT VINE.

At the time when I wrote the paper on the Polyzoa and Foramnifera of the Cambridge Greensand, very little information could be gleaned respecting Polyzoa from the horizons of the Gault, Chalk Marl, or Hunstanton Red Chalk, whilst from the horizon of the Cambridge Greensand no record of a Polyzoan fauna existed. Even as it is, much of our knowledge of the Cambridge Greensand Polyzoa is derived from the study of forms found attached to foreign bodies, or unattached (free) in the phosphate beds of Cambridge. As already stated in the first paper (p. 3), the fossils sent to me for examination and description, were the property of Mr. Thomas Jesson, F.G.S., so in the present case the additions to the fauna of the Cambridge horizons that I am now able to make, I owe to the same gentleman's careful scrutiny of his larger fossils, on which Polyzoan encrustations were found. In addition to these valuable collections, my own cabinet has been gradually enriched by additions of Cretaceous Polyzoa from foreign horizons, so that now I am better able to appreciate the labours of Dr. Goldfuss, Hagenow, and D'Orbigny, whose delineations of Cretaceous Bryozoa deserve our highest admiration. The works of other students, such as Beissel, Reuss, Rœmer, and Simonowitsch have also increased my knowledge of the varied forms of the wide-spread Polyzoa of the Cretaceous epoch. Since 1885, too, other students have been at work on this beautiful group, notably among the rest Dr. Pergens of Belgium, who, having had access to D'Orbigny's original collection, will be able to clear up many difficult problems respecting the minuter work, structural features, &c., of D'Orbigny. Besides this Dr. Pergens has been actively engaged on the correlation and distribution of Cretaceous Bryozoa in the 'Tufeau de Maestricht," "Limsten de Faxe," "Crétáce de la Scanie," and the "Crétáce de la Saxe et de la Bohéme,"* and by the aid of these published lists the palæontologist is now better able to study the ranges of the commoner forms of Cretaceous Polyzoa; but, because there was no more recent list than that of Morris, British Lower Cretaceous species have been, heretofore, only faintly dealt with. For the purpose of this and another paper, I have recently re-examined the collection of Upper and Lower Greensand Polyzoa in the School of Mines. Nearly the whole of these are named in the cretaceous catalogue of that Institution (1878), but in the synoptical table which will precede the descriptive matter I have endeavoured to re-arrange the species, as far as I am able, in accord with the Hincksian classification. This the student of Fossil Polyzoa will be ready to acknowledge is not always possible, for the simple reason that, though the arrangement of the Cheilostomata is to a large extent impregnable, the arrangement of the Cyclostomata has to be modified, enlarged or restricted, according to the age and the horizon of the fossils dealt with. Hence in re-arranging the generic names in the published lists of Morris, and the School of Mines Catalogue, I have made reference to the text and figures of D'Orbigny before doing so. In some few instances I have retained D'Orbigny's generic terms for special groups.

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[*] Part i., Proc. Yorksh. Geol. Soc., Vol. ix., p.p. 1-16, 2 plates.

*** Sur l'age de la partie superieuse du "Tuffeau de Coply." Brussels, 1887.**

In this paper, therefore, I shall confine myself to the Polyzoa of the Upper and Lower Greensands only. I do this for two reasons. The Polyzoa of the Gault, Lower Chalk, Red Chalk, and Upper Chalk must be separately dealt with, as new material is constantly coming to hand, and even the Polyzoa of Farringdon and Warminster would be all the better appreciated if rigidly overhauled. In dealing with the Cambridge Greensand species, now that fairly ample material has been placed in my hands, it will be more advantageous as a palæontological sketch to separately classify, especially in the synoptical table, the Polyzoa dealt with. In the first place many large and small fossils, belonging undoubtedly to the Greensand of Cambridge, are encrusted with colonies of Polyzoa, some of which are very fine. I have before me a list, twenty-four examples at least, sent by Mr. Jesson, and briefly referred to in my first paper (p. 3). These will now constitute true Cambridge Greensand species, and their tabulation will be altogether distinct. The second group of Polyzoa are derived probably from erosion or denudation of rocks of the ages of the Cambridge Greensand and Lower Chalk. In December, 1884, Mr. Jesson wrote me as follows respecting the derived forms. "As to the exact horizon of the Polyzoa from Cambridge I think it is quite impossible to say anything sufficiently accurate to be of any use. They come from the washings of the phosphate beds, but naturally in the excavations there is a great admixture of various horizons. I believe the material came from the Coldhams' Lane Pits." These remarks are all the more valuable, because, having picked from the fine siftings of this *debris* a goodly number of Foraminifera and Entomostraca;* belonging evidently to various cretaceous horizons, a note as to their source may prevent future misunderstanding. The Polyzoa derived from these washings will be tabulated under the head "Phosphate Beds."

Sir Charles Lyell† places the Chloritic Series, or Upper Greensand, at the base of the Chalk Marl, and *above* the Gault. This is the location of the "Cenomanien" division of the Cretaceous Beds by French authors. In his remarks on the series, Lyell says, "According to the old nomenclature this sub-division of the Chalk was called Upper Greensand in order to distinguish it from members of the Neocomien, or Lower Greensand Series below the Gault, to which the name of Greensand had been applied. Besides the reasons before given (265) for abandoning this nomenclature, it is objectionable in this instance as leading the uninitiated to suppose that the divisions thus named, Upper and Lower Greensand, are of co-ordinate value, instead of which the chloritic sand is quite a subordinate member of the Upper Cretaceous group ; and the term greensand has very commonly been used for the whole of the Lower Cretaceous Rocks, which are almost comparable in importance to the entire Upper Cretaceous Series. . . . . The phosphatic bed in the suburbs of Cambridge must have been formed partly by the denudation of pre-existing rocks of cretaceous age."*

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* See Part iii., further on.

† Elements, p. 112 and 226, ed. 1878.

Mr. A. J. Browne† also regards the Cambridge Greensand as the base of the Chalk Marl, it having been formed from the erosion of the Gault by marine currents. Where the Greensand Bed exists the true Upper Greensand is absent, and the Gault is incomplete. Mr. Browne also traces the beds through Cambridge, Bedfordshire, and Buckinghamshire, and shows that in passing from Cambridge S.W. the Upper Gault first appears near Barton, the true Upper Greensand near Tring. The most important factor in this paper, in a palæontological sense, is the list of fossils. These the author divides into two groups : 1st, Those proper to the deposit ; 2nd, Those derived from other horizons. The number of invertebrate species is 254, and 208 or 210 of these are said to be derived, consequently about 46‡ species belong to the Cambridge chloritic deposit, whilst with the remainder their chief affinity is with those of the Upper Gault. These conclusions of the author are, so far, valuable, but the entire absence in the list of any reference to the probable existence of a Polyzoan fauna was perhaps unavoidable at the time, and as far as I am able I will endeavour to supply this faunal deficiency in the present review.

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* Ibid, pp. 282, 283.

† Jour. Geol. Soc. vol. xxxi., p.p. 256, 316.

‡ The lists of Mr. Browne, 1875 and 1881, differ in some few particulars, but as I am not making any special point of this difference, it will be far more satisfactory if the student will look at Mr. Browne's lists before endorsing the above.

The species of Polyzoa enumerated in the Catalogue of the School of Mines* refer to examples in the cases of that Institution; and as these are accessible for the purposes of identification or study, they, as a matter of course, form the groundwork of my present arrangements. In the cases referred to there are many examples, but at least 22 or 23 species are catalogued from the Lower, and 18 or 19 from the Upper Greensand. There are none catalogued from the Gault; only four or five, but unnamed, from the Blackdown beds; none from the Cambridge Greensand, Chloritic Marl, or Red Chalk; and only two from the Lower Chalk. The list of Cretaceous Polyzoa in Prof. Morris's Catalogue of British Fossils† is much fuller for some horizons, and Morris's list appears to be repeated in Phillips' work on the Geology of Oxford and the Valley of the Thames.

In the Rev. W. Downes' paper on the Zones of the Blackdown Beds‡ the author names the following Polyzoa: –

Heteropora dichotoma (Blainv.)?
,, cryptopora, Goldf.
Ceriopora gracilis, Goldf., and
Radiopora bulbosa, D'Orb.

The same species, except the last, with others, which are identified as *Multicrescis*, D'Orb., are found also in the Haldon Rocks of Devon, but are almost indistinguishable on account of the secondary incrustations which obscure the delicate cells of the Polyzoa. Fair examples, however, of the Haldon species are in my own Cabinet.

Mr. C. J. A. Mayer in his paper on the Cretaceous Rocks of Beer Head|| states that Bryozoa occurs in several of the beds examined by him. Thus at Peak Hill (Blackdown Beds?) Bryozoa was found, (p. 372). Several species were also found at Beer Head and Dunscombe, in what corresponds to Warminster Beds and

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* Cat. of Cretaceous Fossils, 1878.

† Ed. 1854.

‡ Quart. Journ. Geol. Soc., Feb. 1882, pp. 75-94.

|| Ibid, vol. xxx., pp. 369-393.

Chloritic Marl, (p. 375). The author also states that many species of Bryozoa are found in other beds, but I notice that in his list of fossils, (p. 386), &c., no Bryozoa are named, therefore, in all probability, the species referred to, (pp. 372-375), are still undescribed, or even unnamed.

In this paper I do not intend to compare or correlate the whole of the Cretaceous Polyzoa, but it may be well to give the summary of known British species as put down by Mr. Robert Etheredge :*—

Upper Chalk	38 genera	50 species.
Lower Chalk	6 ,,	6 ,,
Chalk Marl	1 genus	1 ,,
Cenomanien	15 genera	23 ,,
Gault	3 ,,	4 ,,
Neocomien	21 ,,	34 ,,
Total ...	84	118

This abstract shows the status of scientific investigation on this group, up to date (1885), and when it is compared with the lists given by Morris in his "Catalogue of British Fossils" (1854), the slow advance of our knowledge of British Cretaceous Polyzoa is at once apparent.

Prof. Morris' lists 1854 :—

Upper Chalk	23 genera	45 species.
Lower ,, ...	2 ,,	2 ,,
Chalk Detritus (Charing) ...	5 ,,	5 ,,
Cenomanien (Up. Greensand) ..	5 ,,	5 ,,
Gault ! none.		
Neocomien (Low. Greensand)...	15 ,,	26 ,,
Total ...	50	83

At least nine species enumerated by Prof. Morris are given on the authority of Dr. Sharpe, and just now it would be advantageous to know where the Polyzoa collected by that gentleman are located, as the pit out of which Dr. Sharpe got his Farringdon Fossils is no longer accessible to collectors, and the School of Mines Collection is, therefore, the best known to me. If I am in error I shall be glad to learn so from local or other students.

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* Phillips' Manual of Geology and Palæontology, vol. ii., p. 581, 1885.

The explanation of the tabular list may be briefly alluded to. I have divided the space on the right-hand side into six columns. In the first division I have indicated all the Polyzoa heretofore catalogued by Prof. Morris and Mr. Newton, as belonging to the Lower Greensand, or Neocomien; in the second, Upper Greensand, other than that of Cambridge; in the third and fourth spaces, Chalk Marl and Lower Chalk; whilst the fifth space, separated by double lines from the rest, is reserved for Polyzoa found *encrusting* fossils from the Cambridge Greensand; and the sixth the species found in the phosphate bed, either loose, or adherent to derived fossils. As to the classification of the fossils the general plan adopted is founded to a large extent upon the recent researches of Busk, Hincks, Waters, and Dr. Pergens, but with a few necessary additions.*

The meaning of the symbols used in the columns:—

(×) Recorded in Morris' Cat. Brit. Foss., 1854.
(S) Species in School of Mines, and Catalogue (1878).
(× ×) Species described in this, and in my former paper. Examples in Mr. T. Jesson's Cabinet, and partly in my own.

		Neocom. 1	Up. Gr. 2	Ch. Marl. 3	Low. Ch. 4	Camb. Gr. 5	Phosphate B. 6
	Cyclostomata, Busk.						
	§ 1. Parallelata, Waters.						
	STOMATOPORA, Bronn. = Alecto.						
	linearis, D'Orb.						
1	**var. Mortoni, Vine... ... ...**					× ×	
2	**graciliformis (D'Orb.'s sp.) ... ...**					× ×	
3	**reticulata, D'Orb. ... ...**	S. ×	S. ?			?	
	PROBOSCINA, D'Orb. *Stomatopora*, **Hincks.**						
	dilatata, D'Orb.						
4	**var. Cantabrigiensis, Vine ... ...**					× ×	
5	**ramosa, D'Orb. ... .**	S.				× ×	
6	**cornucopia, D'Orb. ... ...**	S.					
7	**marginata, D'Orb. (Sharp) ... ...**	×					

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* See Classifications, &c., Vine, Proc. Yorksh. Geol. Soc., vi. vol. ix.

		Neocom. 1	Up. Gr. 2	Ch. Marl. 3	Low. Ch. 4	Camb. Gr. 5	Phosphate B. 6
	PROBOSCINA, D'Orb (continued).						
8	sub-elegans, D'Orb. (Sharp)	×					
9	angustata, D'Orb.						× ×
10	elevata, D'Orb. = *P. cornucopia?*	×					
	DIASTOPORA, Lamx. = *Berenicea.*						
11	cretacea, Vine					× ×	× ×
12	Hagenowi, Reuss (near)					× ×	× × ?
13	fecunda, Vine					× ×	× ×
14	„ congesta* stage, (D'Orb.)					× ×	× ×
15	Clementini, D'Orb.					× ×	× ×
16	megalopora, Vine					× ×	× ×
17	papyracea, D'Orb.	S.					
18	ramulosa, Mich.	×					
19	gracilis? Woodw. (D'Orb. ?)	×					
20	tubulus, D'Orb.		S.				
21	Sowerbyi, Lonsd.		S.				
	Bidiastopora, D'Orb. = *Eɩea*, D'Orb.						
22	lamellosa, D'Orb.		S.				
	Entalophora and *Spiropora*						
23	cenomana. D'Orb.	×	S.				
24	costata, D'Orb.	×					
25	meudonensis, D'Orb.	×					
26	ramossisima, D'Orb.	S. ×	S.				
27	Sarthacensis, D'Orb.	×					
28	annulata, Rss. = Cricopora		×				
29	echinata, Rss.			×			
30	madreporacea, Goldf.			×			
31	Francqana? D'Orb.		S.				
32	micropora, D'Orb.		S.				
33	proboscidea, Edw.						× ×
34	var. elegans, Vine						× ×
35	Jessoni, Vine						× ×
36	neocomiensis, D'Orb.						× ×
37	lineata, Beissel						× ×
38	var. striatopora, Vine						× ×
39	gigantopora, Vine (As Proboscina, id., also)†					× ×	× ×
40	gracilis, Goldf. = Ceriopora		×				
	Filisparsa, D'Orb.						
41	ornata, Reuss.						× ×
	Hornera, Lamx.						
42	carinata, Reuss.		×				
	Peripora, D'Orb.						
43	pseudospiralis, Michelin	×					

* See remarks on this form, 17a, in text, p. 269.

† See text; page 262.

		Neocom. 1	Up. Gr. 2	Ch. Marl. 3	Low. Ch. 4	Camb. Gr. 5	Phosphate B. 6
	Idmonea, Lamouroux						
44	dorsata? Hag.						× ×
45	clathrata, Goldf.		×				
	Truncatula, Hagenow						
46	repens? Hag.						× ×
47	pinnata, Rœm.		S.				
	§§ Rectangulata, Waters.						
	Heteropora, Blainville						
48	tenera, Hag. = *Multicrescis*	S. ×					
49	mamillata, D'Orb. ,,	×					
50	variabilis, D'Orb. ,,	×					
51	cryptopora, Goldf. ,,		×				
52	undata, D'Orb. *Zonopora*	×					
53	michelini, D'Orb. *Multicrescis*	S.					
54	ramosa, D'Orb. ? (semi-multicrescis)	S.					
55	clavula, Mich.	S.					
	Ceriocava? D'Orb. = Ceriopora (pars.), Goldf.						
56	irregularis, D'Orb.	×					
57	ramulosa, D'Orb. *Chœtetis*, Mich.	×					
58	mamillosa, Rœm	×					
59	polymorpha, Goldf. = *Ceriopora*	S.	S. ×				
60	Raulini, Mich. = *Echinocava*	S.					
61	cavernosa, Hag.	S.					
62	collis, D'Orb. REPTOMULTICAVA	×					
63	mamilla, D'Orb. ,,	×					
64	micropora ,,	×					
65	avellana (?) Mich.	S.					
	The British examples of the following forms require to be re-studied and re-described.						
	Reptocea, D'Orb.						
66	cenomana, D'Orb.	×					
	Petalopora, Lonsdale.						
67	pulchella, Rom.		S.				
	Osculipora, D'Orb.						
68	plebeia, Novak						× ×
	Radiopora, D'Orb.						
69	pustulosa, D'Orb.	×	S.				
70	bulbosa, D'Orb.	S.					
71	heteropora, D'Orb.	S.					
	Domopora, D'Orb.						
72	clavula, D'Orb. (Diastopora, Morris)	×					
73	tuberculata, D'Orb.	×	×				
74	polytaxis (?), Hag.						× ×

		1 Neocom.	2 Up Gr.	3 Ch. Marl.	4 Low. Ch.	5 Camb. Gr.	6 Phosphate B.
	Lichenopora. = *Actinopora* (pars.), D'Orb.						
75	papyracea, D'Orb.	×					
76	radiata, Aud. *Discoporella*, Busk ...					× ×	× ×
77	? elegans. D'Orb. *Lopholepis*, Hag. ...	S.					
78	compressa ? D'Orb.						× ×
	I am not satisfied as yet where the following should be placed.						
	Umbrellina, Reuss.						
79	paucipora, Vine. = *Lichenopora id* ...						× ×
	The following species also want working:—						
80	Discocavea Neocomiensis, D'Orb.	S.					
81	Laterotubigera cenomana, D'Orb. ...		S.				
82	Siphodictyum gracile, Lonsd.	S.					
	Besides these there are several forms of *Diastopora*, *Entalophora*, *Stomatopora*, and *Proboscina* species still unworked in the cases of the School of Mines.						
	CHEILOSTOMATA, Busk.						
	Membranipora						
	,, Dumerilla, Aud.						
83	,, ,, var. cantabrigiensis, Vine					× ×	× ×
84	,, cretacea, D'Orb.					× ×	× ×
84a	,, ,, var. Francqana, D'Orb.				×	× × ?	× ×
	Vincularia, Defr.						
85	Bronnii, Rss.			×			
	Microporella, Hincks.						
86	antiqua, Vine					× × ?	× ×
87	? dispersa, Reuss. *Escharina*, Ed. ...		×				
	Eschara						
88	cybele, D'Orb.		S.				
	Doubtful species.						
89?	Spinopora Dixoni, Lonsd.	S.	S.		×		
90?	Lunulites cretacea (?)	?	?			× ×	× ×

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1874. ,, Die Foraminifera und Bryozoen, und Ostrocoden des oberen Pläners. These papers in the text quoted as "Pläners," 1872 or 1874.

1862. Reuss, Uber Tert. Bryozoen von Kischenew in Bessarabien. For Diastopora *corrugata* and *D. congesta*. Tertiary forms.

1887. J. Jukes Browne and W. Hill. On the Lower Beds of the Upper Cretaceous Series in Suffolk and Norfolk. Quart. Jour. Geol. Soc., vol. xliii.

1888. W. Hill and A. J. J. Browne. Up. Cret. Beds in Lincolnshire. Quart. Jour. Geol. Soc., vol. xliv.

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Sub-Order CYCLOSTOMATA.

Division A. Parallelata, Waters.

1. Idmonea dorsata? Hagenow.

Camb. Greensand Paper, Proc. Yorksh. Geol. Soc., vol. ix., p. 5.

Horizon: Phosphate Beds, Cambridge.

2. Truncatula repens? Hagenow. Vine, Proc. Y. Geol. Soc., vol. ix., p. 13.

Horizon: Phosphate Beds, Cambridge.

3. Entalophora proboscidea, Edw.

= Entalophora raripora, Vine, Proc. Y. Geol. Soc., vol., ix., p. 5.

This species is present in the Camb. Greensand material, together with what appears to me to be a variety of the same species. Dr. Pergens* includes in his identification of *E.* (Pustulopora) *proboscidea*, Edwards, a long list of synonymous forms, and *E. raripora*, D'Orb., is one of these.

Horizon: Phosphate Beds, Cambridge.

4. Entalophora proboscidea, Edw.

Var. elegans, Vine, Proc. Y. Geol. Soc.. vol. ix., p. 5, pl. i., figs. 1 and 2.

There are certain features in the species formerly described by me, as *E, raripora*, that seem to warrant its separation from the ordinary typical forms, which, generally speaking, are delicately punctured in horizontal lines across the surface of the *Zoœcia*. The variety now separated from ordinary examples of the type have well-marked facial characters.

Horizon: Phosphate Beds, Cambridge.

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* **Bryozoaries de Faxe, 1886, p. 202.**

5. Entalophora lineata, Beissel.

1864. E. lineata, Beiss; Bryoz. der Auchner, Kreidbildung., p. 80, pl. ix., figs. 116-119.

1872. Stoliczka, Palæont. Indica : iv. (2). "The Cilopoda."

1874. Reuss (var.) Bryoz. und Ostracoda des "Planers," p. 133. pl. ii., figs. 5-6.

1887. Clinopora lineata, Marsson Bryoz. Schreibkreide, Rugen, p. 24.

The type species of Beissel was found in Senonien Rocks, "Kreidmergal ohne Fenerstein; Froedrichberg, Preusberg, Vaels," and is described as rare. Stoliczka's were from the "Arria loor gruppe bei Yermamoor in Ostindein; whilst the variety described by Reuss is stated to be rather rare in the "Planers" of Strechlen and Wheinböhlla. Marsson, however, makes a new genus, *Clinopora*, for the inclusion of *Entalophora*, with longitudinal striae on the outer surface. He describes two species *Cl. lineata*, Beiss, and *Cl. costulata*, Mars; the last of these would, in all probability, embrace Reuss's variety also.

Beissel's species, *E. lineata*, with its elongated *Zoarium*, very few Zoœcia in the branch, and faintly striated between cell and cell, is present both in the Phosphate Beds material, but rather rare, and in the Upper Chalk of Chatham. Having restudied all the British forms, I am inclined to keep them separated as above, and the variety as follows.

Horizon: Phosphate Beds, Cambridge.

6. Entalophora lineata, Beissel.

Var. striatopora, Vine.

=E. striatopora, Vine, Camb. G. S. Pap., Op. Cit., p. 6, p. 1, fig. 5.

This beautiful variety is so different from the typical species of Beissel, or *Clinopora* species of Marsson, that I think it will be wise to make a distinction as above. Examples are fairly plentiful in the Cambridge material.

Horizon: Phosphate Beds, Cambridge.

7. Entalophora Jessoni, Vine, Camb. Gr. Pap., p. 6, pl. i., fig. 6.

There is certainly a family likeness in all the *Spiropora* species of Fossil Polyzoa. D'Orbigny gives several forms, all of which are well marked, but the present species must not be confounded with others of the class.

Horizon: Phosphate Beds, Cambridge.

8. Entalophora neocomiensis (?), D'Orb.

=Entalophora neocominensis (?) (error), C. G. Pap. 7, pl. i., fig. 4.

1852. ? Entalophora neocomiensis, D'Orb., Terr. Cret., p. 782, pl. 616, figs. 15-18.

This species is not abundant in the Cambridge material, but I am not certain that I should be justified in removing the (?) from the name. I have compared my own with D'Orbigny's figure and description of *E. neocomensis*, D'Orb., and I am not satisfied that the two are identical.

Horizon: Phosphate Beds, Cambridge.

9. Entalophora gigantopora, Vine, C. G. Pap., p. 8, pl. i., fig. 3.

Since the account in my former paper was written I have re-examined the fossil referred to (p. 3). On a fine example of *Pharetrospongia strahani*, Sollos, I have found a decumbent colony of what I believe to be the early stage of this species. The cells are large, similarly arranged, and the colonial growth covers fragments of the network of the sponge. At some of the places in the sides of this *Proboscina* stage there is evidence that portions of the Zoarium became free, and erect, and thus the flattened form passed into another, a Bi-Diastopora, or an Entalophoridian stage. All the examples that I have heretofore found free are apparently broken from these erect lateral growths, and until now the *Proboscina* stage of this large Zoœcial form has escaped notice.*

Horizon: Cambridge Greensand Phosphate Beds. Free forms.

10. Stomatopora linearis, D'Orb., Terr. Cret., t. v., pl. 629, figs. 5-8.

Var. MORTONI, var. n, pl. xii., figs. 1 to 1d.

Stomatopora linearis, D'Orb., and *S. rugulosa*, Reuss, in some respects resemble the Cambridge Greensand form, but from the descriptions of D'Orb it is impossible to place the British variety under either name without remark.

Zoarium linear, or slightly flexous; unbranched. *Zoœcia*, long, and tapering towards the proximal extremity, occasionally bulging and contracted towards the distal, surface faintly punctate, orifice rather less than the breadth of the cell, peristome raised.

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* Recently I have found a similarly decumbent form in the Red Chalk, which I have named Proboscina gigantopora, Vine.

Length: 4 cells measure slightly over a quarter of an inch.

Breadth: Less than 1 mm.

Habitat: On the inner portion, and outer lip of *Radiolites Mortoni*, Mant.

Horizon: Cambridge Greensand.

S. linearis, D'Orb. Loc.: Havre. Cenomanien. Etage 20e.

This beautiful variety I have named *Mortoni*, on account of its peculiar habitat, but another small fragment (figs. 1c and 1d) was found in the inner portion of a dead ostrea, likewise attached to *Radiolites Mortoni*. The two forms appear to be identical. On the outer lip of the same fossil was a very large colony of *Membranipora Dumerilla*, Aud., var. *Cantabrigiensis*, Vine, as well as colonies of Diastopora.

11. Stomatophora graciliformis* (D'Orb. sp.), pl. xii., figs. 2 to 2b.

1848. = Stomatophora gracilis, Bronn (D'Orb.), Terr. Cret., p. 843.

1850. = Alecto gracilis, D'Orb., Terr. Cret. ibid, pl. 629, figs. 1-4.

This species, so far as I am acquainted with it, is always small or delicate, and very distinct. The *Zoarium* branches frequently, almost every cell, or at most two cells, branch off irregularly. The *Zoœcia* are slightly rugose, short, but occasionally 1 mm. in length, and tapering towards the proximal extremity. The general habit of the species more closely resembles the *Alecto gracilis*, D'Orb., than any other that I am acquainted with.

Habitat: On the smaller examples of *Radiolites Mortoni* Mant.

Horizon: Cambridge Greensand.

D'Orbigny's *S. gracilis* is from Meudon, in Senonien Rocks. Etage 22e.

12. Proboscina dilatata, D'Orb.

1850. *Idmonea* dilatata, D'Orb. Tert. Cret., t. v., p. 851, pl. 632, figs. 4-6.

Var. cantabrigiensis, var. n. pl. xii., figs. 3-3a, 4-4a.

Zoarium adherent, ramified, originating from a short stem from which two very simple branches dilate on either side, but unlike *P. dilatata*, these do not diverge at any great angle. From the centre of these two branches a larger flabellate, alternately diverging, branch is developed. The whole colony is about 15 mm. in length, and between 4 and 5 mm. in breadth at the widest part. *Zoœcia* elongate, contiguous, slender, two of which measure about 1 mm. in length; series of cells in the branches varying from 1 to 3 in the originating, to 8 or 10 in the wider portions. With the hand-glass I was unable to detect any puncture in the cells, and the fossils to which the species is adherent, is too large to place under the microscope.

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* I have adopted this name to keep the species distinct from that of M. Edwards.

Habitat: On the inner side of *Radiolites Mortoni* Mant.

Horizon: Cambridge Greensand.

Proboscina dilatata, D'Orb., is from Mans. Cenomanien., Etage 20e, and is found in company with *P. ramosa*, D'Orb. Terr. Cret., t. v., p. 851, pl. 632 and 633.

This species or variety certainly differs from D'Orbigny's *P. dilatata* in its general habit, so far as it is figured by the author, but the description in the text, p. 852, agrees to some extent with that of the British form. Still there is a difference, and I prefer to give the above a varietal name. I have only seen three examples of this beautiful Polyzoon, and these are close together on one fossil. Figs. 3 and 4 of the plate are first rubbed with damp paper, and the impression etched as figured. A similar varietal form to this is found on an *Inoceramus* from the Red Chalk, Hunstanton, but unless I had seen the forms now described I should not have been able to identify the Red Chalk one, as only a mere impression of the once existing colony is left on the shell.

13. Proboscina ramosa? D'Orb., pl. xii., figs. 5 to 8.

= Diastopora ramosa, Michelin (?), Icon. Zooph., p. 203.

1850. Diastopora ramosa, Lonsd., Dixon's Geol. Sus., p. 295, tab. xviiiB. figs. 1-1b.

1847. Idmonea ramosa, D'Orb., Prod. 2, p. 175.

1850. Idmonea cenomana, D'Orb., Voy., pl. 633, fig. 1-3.

1852. Proboscina ramosa, D'Orb., Terr. Cret., t. v., pl. 632, figs. 1-3, pl. 633, figs. 1-3.

There are present on one of the smaller examples of *Radiolites Mortoni* several colonies of a *Proboscina* species, which, if not identical, are closely related to *I. ramosa*, D'Orb., less so with *Idmonea cenomana*, of the same author. Fig. 8 appears to be the top part of one of the branches. Reuss describes and figures a form somewhat similar to the Greensand example, *Proboscina graciles*, Reuss, but I cannot compare the British form so favourably with Reuss's as with D'Orbigny's figures.

Habitat: On Radolites Mortoni.

Horizon: Cambridge Greensand.

Proboscina ramosa, D'Orb., is from Mans; Cenomanien.

Lonsdale's example, *Diastopora ramosa*, from the Upper Chalk.

14. Proboscina angustata, D'Orb.

1850. Idmonea angustata, D'Orb., Terr. Cret., p. 852, pl. 632, figs. 7-9.

1852. Proboscina angustata, D'Orb., Ibid.

1872. Proboscina angustata, Reuss, Bryoz. &c. des Planers, p. 113, tab. 28, figs. 3-4.

1885. Stomatopora gracilis, M. Ed. (?) Vine, Camb. Gr. Pap., p. 4, pl. ii., fig. 7.

I had only one example of this species, and that a poor one, but a re-examination of the form induces me to locate it here rather than leave it, even doubtfully, with Milne Edwards' *S. gracilis.* D'Orbigny's figure represents the species as having two rows of cells in the whole of the branches, but Reuss figures his example as partly uniserial (fig. 3), and partly biserial (fig. 4), in this respect the "Planers'" example resembles the British.

Horizon: Phosphate Beds, Cambridge.

Locality: *Proboscina angustata*, D'Orb., is from Mans, and is found in company with *P. ramosa*, and *P. dilatata*, D'Orb.

15. Diastopora cretacea, Vine.

1883-4. Brit. Association Report. Fossil Polyzoa.

1885. Camb. Greensand Paper. (Op. Cit.), p. 9.

An example similar to the one originally described from the

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* **Die Bryoz. des unteren Quaders, 1872, p. 113, pl. 28, figs. 6-9.**

Upper Chalk, is present in the Cambridge material on a fragment of Inoceramus, but evidently derived from Lower Chalk Beds above.

Habitat: On Inoceramus, and on an Echinoderm.

Horizon: Lower Chalk? Cambridge: Upper Chalk, Sussex.

16. Diastopora Hagenowi, Reuss, pl. xii., figs. 9-9b.

1872. Bryoz. des unteren "Planers," p. 109, pl. 26, f. 12.

1885. D. cretacea, var. lineata, Vine. Camb. G. Pap., Op. Cit,, p. 9.

On the same fragment of *Inoceramus* is a smaller and more disk-like species than *D. cretacea*, which closely resembles in all its characters *D. Hagenowi*, Reuss. There are also two examples of this species on a large specimen of *Radiolites Mortoni*, but these are irregular in their habit and not disk-like, but the cell arrangement are similar to the "derived" form. I do not think it wise to separate them.

Habitat: On Inoceramus, and Radiolites Mortoni.

Horizon: Lower Chalk? Cambridge, and Cambridge Greensand.

17. Diastopora fecunda, Vine, Camb Gr. Paper (Op. cit.), p. 9.

In the above paper I described this species at greater length than the others, but because there are certain forms of *Diastopora* somewhat similar to the above, both in the works of D'Orbigny and Reuss, I have re-studied the examples again, with the following results. In his 1846 paper (Boheme Kreide, pl. 15, fig. 42), Reuss illustrated a peculiar *Diastopora*, which he named *D. congesta*, and another in the same work (pl. 15, fig. 41), *D. confluens*. This last species or variety is the *Rosacilla confluens*, Rœmer (1841). D'Orbigny adopted the name *D. congesta* (Voyez, 1847), which followed afterwards as *Reptomultisparsa congesta* (Terr. Cret., vol. v., p. 878, pl. 640, figs. 1-6). Reuss in 1872 (Die Bryoz., &c., "Planers," p. 110), united the whole of these forms, together with *Reptomultisparsa glomerata*, D'Orb., under one name, *Berenicea confluens*, Rœmer's sp. The chief characteristic feature of all these varieties is, they are either proliferous, with cells rather distinct in the Zoarium, or blended together, or contiguous, which can be better seen in sections. Novak (Bryoz. der Bohem. Kreide., p. 97, pl. iv., figs. 1-10) describes and illustrates a new species, which in many senses is most peculiar, both in growth and cell arrangement as *Berenicea pilosa*, and in his text

Novak comments on three other species characterised as distinct by Reuss and D'Orbigny ; *Berenicea Clementina* and *grandis,* D'Orb., and *B. conferta,* Reuss. The whole of these species are found in the Planer-Kalk* of Germany. In establishing *Diastopora fecunda* as a new species, whether new to the Cambridge Greensand of Britain only, or new, generally speaking, to the Lower Cretaceous horizon, Continental or British, remains to be seen. The forms which I have characterised by this name are the most abundant of the Camb. Greensand species whether attached or free, and they are the most variable. When briefly remarking on the structural features of prepared sections I wrote as follows :—"In a semi-transparent section of *D. fecunda* . . . . . . the peculiar structural features of the species are very apparent. The super-imposed colonies originate from marginal cells, and the initial stage of a new colony is flabellate and ultimately disciform, the new colony entirely obliterating or covering up the original." (Camb. Gr. Pap., p. 10, op. cit.) The profile outline of some of the examples of *D. fecunda,* Vine, closely resemble some of the "natural size" figs. of *Berenicea confluens* Roëm sp. (Novak, p. 98, pl. iv., figs. 19-22). and the cells in transparent sections that I have recently prepared are certainly "confluent," but this is not the sense of the word, I take it, as used by Novak. Novak appears to refer to the outward surface, and not to any sectional characters. If I do not mistake his meaning then, the *Berenicea*† *confluens* of Roemer, Reuss, or D'Orbigny, is not the *Diastopora fecunda* of British rocks. Having pointed out to the student what *D. fecunda is not,* I will now point out what the species is. In trying to diagnose the characters of the form I did my best to do it briefly, but a careful re-examination of the whole of my own and Mr. Jesson's "free," not the adherent examples which could not be placed under the microscope, I find certain characters in some of them which may, or may not be, regarded as separate species, but they may perhaps be regarded as varietal.

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* "Planer-Kalk," the German name for the white argillaceous chalk, a deposit which resembles both in composition and organic remains, the Chalk-Marl of the English series. Lyell. Elements, p. 276 Ed. 1878.

† Rosacilla Roem : Reptomultisparsa, D'Orb. ; Diastopora and Berenicea Reuss.

(*a*) Normal (or typical?) "Zoœcia variable, elongated, but rarely exposed except at the distal extremity of the cell; orifice circular . . . or slightly elongated (worn), peristome thin, not prominent; cells not wholly contiguous; sparsely punctured." (C. G. Pap., op. cit., p. 10). This is the general character of the "basal" colonies of the dome-shaped *D. fecunda.*

(*b*) Young, or newly-formed colonies on the apex of the dome. These are variable, and some of them simulate the features of what now passes for two distinct species. In one stage of these newly-formed colonies I find most of the features of the species characterised as *Berenicea Clementina*, D'Orb. (Terr. Cret., p. 865, pl. 636, figs. 1-2. The cells are not quite so contiguous, but the colonies are either "discoid" or "flabeliform," and are marked (rugose?) transversely like D'Orbigny's, fig. 2. In another colony I have traced similar characters to Novak's *Berenicea pilosa* (Bohm., Kreid., p. iv, figs. 1 to 10), but more especially the raised peristomes with "hair-like" markings on the front, like the fig. 5 of pl iv.,; other cells are marked with "pilosa" markings like fig. 4, but the Zoœcia are neither so long nor so contiguous as is represented in that figure. There is, apparently, another stage in some of these younger colonies, the *Berenicea conferta* stage, but as examples of these are not so well marked or so characteristic as the others they may be only passingly referred to here. Whether, as I have already remarked, I should be justified in ranking the smaller colonies as separate species, or whether I should leave them as mere abnormal growths, with distinct specific features, may be now briefly considered. In these smaller colonies I have not been able to trace any of them as passing from one form to another, but nearly the whole of the forms referred to are found, (parasitic?) on *Diastopora fecunda.* One of the so-called "stages," *B. Clementina* stage, however, seems to be rather more constant, and this species of D'Orb. may, I think, be safely considered as being present in the Cambridge Greensand material; but of the others I am somewhat doubtful of their right to be ranked as distinct, or to find a place in the lists of the British Cretaceous Polyzoa fauna. What I have said already may induce others to overhaul their Cambridge Greensand Fossils, and if satisfied, publish the results of their investigations.

Habitat: Free; Phosphate Beds: Attached on *Pharetrospongia strahani*; and on Ostræ valve adherent to *Radiolites Mortoni*.

Horizon: Camb. Greensand; Phosphate Beds, Cambridge.

17a. Diastopora fecunda (*D. conjesta* stage, D'Orb.), pl. xii., figs. 10 to 10b.

= D. conjesta and D. confluens, D'Orb., pl. (Terr. Cret.) 640, figs. 1-6.

These figures are drawn from one of the most conspicuous of the apical (or young growths) of *D. fecunda*, Vine. and represents the *D. conjesta* stage of D'Orbigny. See plates in Atlas as above.

18. Diastopora Clementina, D'Orb.

1847. Diastopora Clementina, D'Orb., Prod. 2, p. 120, and Voyez.

1852. Berenicea Clementina, D'Orb., Terr. Cret., v., p. 865, pl. 636, figs. 1-2.

1872. Berenicea Clementina, Reuss, "Planers," p. 109, tab. 26, f, 8.

I have examined, besides the small parasitic colony previously referred to above, two very fair examples of this species, and these are sufficiently characteristic to warrant their inclusion in this list. One of the examples have the cells more closely packed together than the other; Zoœcia faintly rugose; Zoarium variable.

Habitat: One on an Ammonite, the other on D. fecunda.

Horizon: Phosphate Beds, Cambridge.

19. Diastopora megalopora, Vine, Camb. Greensand Pap. p. 10, pl. ii., figs. 9-9c.

This is a distinct type of Cambridge Greensand Diastopora, and its facial characters have been already depicted. One rather large example of the species, derived probably from the Chalk Marl, as well as showing some of the Zoœcial characters referred to previously, give us a really good idea of the constancy of its typical features.

Horizon: Phosphate Beds, Cambridge. (But derived from Chalk Marl).

(Diastopora confluens, Reuss, Camb. Greensand Paper, p. 10. On account of what has been already said in speaking of *D. fecunda* this species is suppressed, and *D. Clementina* substituted in its place).

20. Umbrellina paucipora, Vine.

= Lichenopora ? paucipora, Vine, Quart. Jour. Geol. Soc., Nov., 1884, p. 853, with fig , drawn by Mr. Busk.

= Lichenopora ? paucipora, Vine, C. Gr. Pap., p. 11.

There is no species in the whole of the Cambridge collection that I have had more bother with than the above. At the time I wrote the above papers I was not familiar with Reuss's peculiar genus *Umbrellina*, which the author established for the reception of one species only. In the classification of Reuss (1872, Bryoz. &c., des unteren Planers) the genus is placed in the Fam. Entalophoridæ. The species is named *U. Stelzneri*, Reuss, and in company with his, other peculiar forms are suggestively placed.

? Clypeina tubæformis, Lonsd. (Dixon's Geol. Sus.), and

. ? ,, marginoporella, Mich. Icon.

The British examples differ materially from the *U. Stelzneri*, Rss., more especially in the longitudinal aspect. The disk-like upper part is also different, and if it be not sufficiently distinct to be recognised as a new species, it is, at least, a variety of Reuss's species, rather than identical with it.

Horizon: Phosphate Beds, Cambridge.

21. Osculipora plebeia Novak., Vine, Camb. Gr. Pap., p. 13.

Examples of this species are very abundant in the Cambridge material, but I have not been able, however, to establish all the variations of form which Novak depicts, neither have I found any examples bearing ovicells.

Horizon: Phosphate Beds, Cambridge; Bohemia, Novak.

§ RECTANGULATA, Waters.

22. Domopora polytaxis, Hag. Vine, Camb. Gr. Paper, p. 12.

Horizon: Phosphate Beds, Cambridge.

23. Lichenopora compressa ? D'Orb., pl. xii., figs. 11-12a.

1852. Discocavea compressa, D'Orb., Terr. Cret., t. v., p. 961.

Lichenopora compressa, D'Orb., pl. 645, figs. 5-8.

In some respects, particularly in the lines of growth as represented in the figures of D'Orb , the British form resembles the Senonien as given, figs. 5, pl. 645. There are ample varietal differences in the two I will admit, but from one poor example it is difficult to make out the necessary details so as to establish a variety.

Horizon: Phosphate Beds, Cambridge; Dans l' etage senonien, a Meudon.

24. Lichenopora radiata (?) Aud., or variety, Vine, Camb. Gr. Pap., p. 11.

Horizon: Phosphate Beds, Cambridge.

Sub-Order CHEILOSTOMATA, BUSK.

25. Membranipora Dumerilli, Aud.

Var. Cantabrigiensis, Vine, C. G. Pap., p. 14, pl. ii.

On the example of *Radiolites Mortoni* previously referred to, under *Stomatopora linearis*, var. *Mortoni* (ante.) there is a large colony of this peculiar species. There is not any appreciable difference between this and the other examples described in the former paper, only as this is attached the additional horizon for the species has a certain historical value that will be, I think, appreciated.

Habitat: On Radiolites Mortoni, Mant.

Horizon: Cambridge Greensand and Phosphate Beds.

26. Membranipora cretacea, D'Orb.

1851. Flustrellaria cretacea, D'Orb., Terr. Cret., v., p. 519, pl. 724, figs. 5-8.

On several fossils belonging to the Cambridge Greensand horizon I have found colonies of Membranipora, rather small—but, so far as I have examined them by the hand-glass—characteristic. These seem to me to be allied to, if not identical with, two of D'Orbigny's types. One of the forms with oval cells, with thin walls and cells arranged pretty regular in diagonal lines, I place here.

Habitat: On Radiolites Mortoni.

Horizon: Cambridge Greensand.

27. Membranipora cretacea.

var Francqana ? D'Orb.

1851. Flustrellaria Francqana, D'Orb., Terr. Cret., v., p. 525, pl. 725, figs. 13-16.

The cells of this variety are similar to the last, only some of the cells depicted by D'Orb. are a little more compressed, or bulging at the extremities, than the typical form.

Same Habitat and Horizon.

28. Microporella antiqua, Vine.
= Microporella sp. (? antiquata) Camb. Green. Pap., p. 15, pl. ii., f. 11.

Besides the original fragments described above, I have found another small example attached, which I believe belongs to a similar, if not to the same species of Microporellidœ. It encrusts a portion of the base of a Gorgonia, but, excepting the shape of two or three of the cells, which are similar to the fragment already described, the colony is otherwise indistinguishable.

Habitat: On Gorgonia base, and on Fragments of Echinoderm spine.

Horizon: Phosphate Beds.

(Part II., FORAMINIFERA, Camb. Gr. Paper, p. 16).

A few errors crept into the second part of my Cambridge Greensand Paper, which, through the kindness of Prof. T. Rupert Jones, I am now able to correct. The species described by me were :—

21. Webbina tuberculata, Sollas.
22. ,, lœvis, Sollas.
23. Trochammini helveto-Jurassica, Hausler.
24. Textularia agglutinans, D'Orb. Of these No. 23 should have been *Lituola irregularis,* Rœmer.

Part III.

Foraminifera and Ostracoda from the Greensand and Chalk-Marl of Cambridge. [Phosphate Beds.]

The following lists of Foraminifera and Ostracoda from the Cambridge Phosphate Beds ("Coldhams' Lane Pits," T. Jesson, F.G.S.), I am enabled to publish through the kindness of Prof. T. Rupert Jones, F.R.S., and C. D. Sherborn, F.G.S. Within the last few months (June to Nov., 1889) I have re-examined much of the finer *débris* from the above beds, and picked out a large number of individuals of species belonging to the before-mentioned groups. Many of these were mounted separately, and then submitted to Prof. T. R. Jones, who, with the help of Mr. Sherborn, carefully tabulated for me the whole of the specific names now published. It is not likely that I shall ever work over the *débris* again, and in the interests of Palæontological research I offer my sincere thanks to all who have helped me to complete these amended lists of species found in Greensand and Phosphate Beds of Cambridge. The total results are as follows :—

Foraminifera	... ...	17 genera	31 species.
Polyzoa	... ...	12 ,,	28 ,,
Ostracoda	... ...	6 ,,	13 ?[*] ,,
		—	—
		35 genera	72 species.

A. Foraminifera.

1. Triloculina (near T. tricarinata, D'Orb.)
2. Lituola irregularis, Rœmer.
3. ,, globigeriniformis, Parker and Jones.
4. Reophax (single joints).
5. Webbina lævis, Sollas.
6. ,, tuberculata, Sollas.
7. Textularia agglutinans, D'Orb.
8. ,, fœda, Reuss.
9. ,, turris, D'Orb.
10. ,, trochus, D'Orb.
11. Gaudryina pupoides, D'Orb.
12. Verneuilina triquetra, Münster.
13. ,, Parisiensis, D'Orb.
14. Bulimina obtusa, D'Orb.
15. ,, Murchisoniana, D'Orb.
16. ,, elegans, D'Orb.
17. ,, obliqua, D'Orb.
18. Globigerina bulloides, D'Orb.
19. ,, cretacea, D'Orb.
20. Planorbulina ammonoides, Reuss.
21. ,, Clementiana, D'Orb.
22. ,, grossirugosa, Gümbel.
23. Cristellaria rotulata, Lamarck.
24. ,, cultrata, Montfort.

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[*] Including the two varieties of *Cythereis*, Nos. 9-10.

25. { Frondicularia bicornis, Reuss,
  ,, "var. with two parallel longitudinal ribs," Jones.
26. Flabellina Cordai, Reuss.
27. Vaginulina costulata, Reuss.
28 ,, ,, var. near V. incompta, Rss.
29. Nodosaria Raphanus, Linné.
30. Dentalina communis, D'Orb.
31. Lagena marginata, D'Orb.

With the exception of Nos. 1, 4, 9, 26, 29, and 31, the whole of the above species are rather common in the Phosphate *débris*; No. 26 is very rare; and 23 and 24, especially No. 23, literally swarm in the material, and examples may be picked out by thousands.

B. OSTRACODA.

1. Bairdia Harrisiana, Jones.
2. ,, subdeltoidea. Münster.
3. Cytheropteron concentricum, Reuss.
4. ,, ,, var. virginea, Jones.
5. Cythere Harrisiana, Jones.
6. Cythereis triplicata, Rœmer.
7. ,, quadrilatera, Rœmer.
8. ,, ornatissima, Reuss.
9, ,, ,, var. A.
10. ,, ,, var. B.
11. Cytheridea perforata, Rœmer.
12. Cytherella ovata, Rœmer.
13. ,, truncata, Bosquet.

Though some of the above Ostracoda are rather plentiful in the Phosphate *dbéris*, others are very rare. None of them, however, are so abundant as individuals as the Foraminifera

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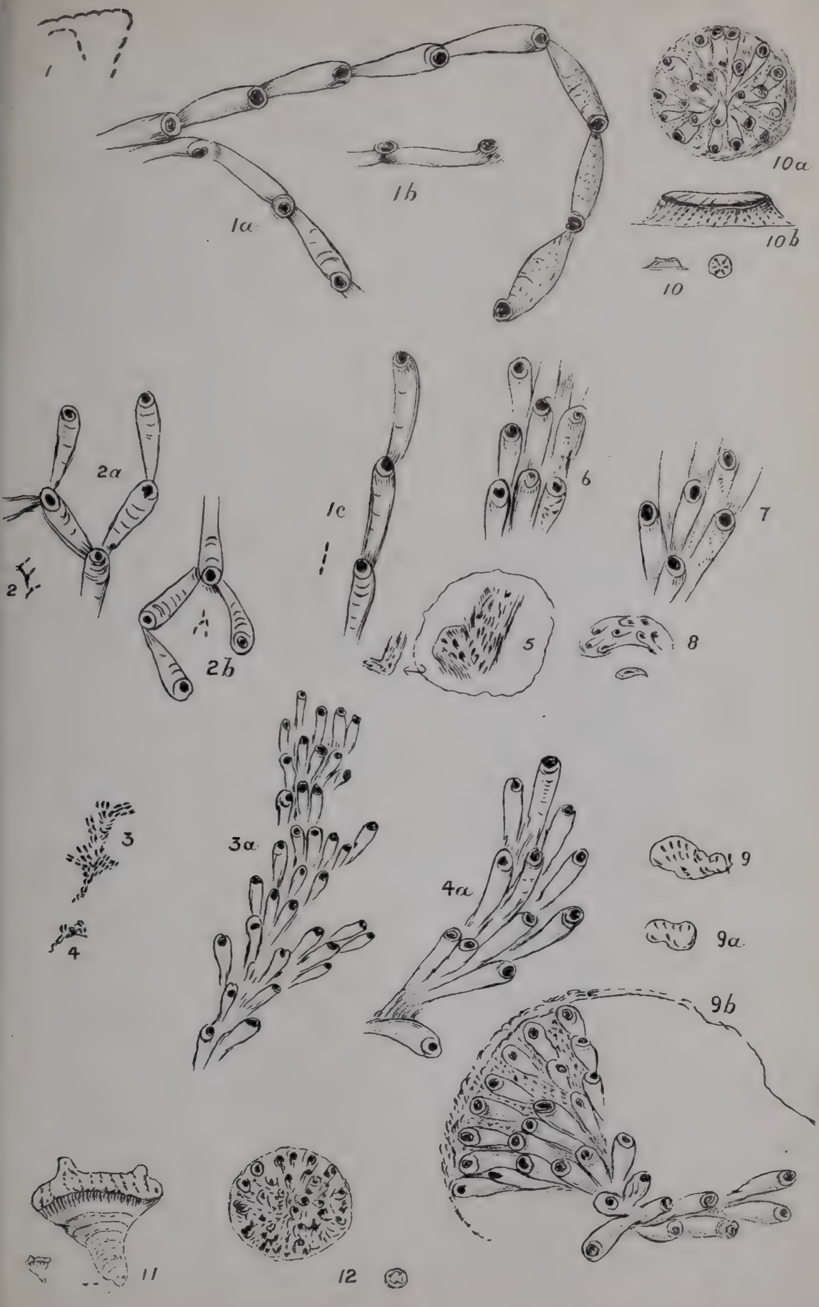
EXPLANATION OF PLATE.

Figs.
1-1c. Stomatopora linearis, D'Orb.
Var. Mortoni, Vine.
2-2b. ,, graciliformis (D'Orb. sp.) (= S. gracilis, D'Orb.)
3-3a. Proboscina dilatata, D'Orb.
Var. Cantabrigiensis, Vine.



Vine: Polyzoa of the Greensands.

4-4a.	Proboscina ,, another colony of the same.	
5.	,, ramosa, D'Orb.	Various characteristic fragments of this species.
6.	,, ,, ,,	
7.	,, ,, ,,	
8.	,, ,, ,,	
9-9b.	Diastopora Hagenowii, Reuss.	
10-10b.	,, fœcunda, Vine. Very young example.	
11.	Lichenopora ? compressa, D'Orb.	
12.	,,	

GLACIAL SECTIONS NEAR BRIDLINGTON. PART IV.

BY G. W. LAMPLUGH.

Introduction.—In writing the last paper of this series in 1883, I surmised that with it the series would probably close, but since that time events have happened which render it advisable that I should add one more part, making the fourth. In doing so, I think it will be profitable first to glance at the ground already covered by these papers. The primary object of the series was, as stated in Part I., to describe sections in the neighbourhood of Bridlington, which were 'likely to be destroyed, either by artificial or natural means,' to give careful sketches where the beds seemed complicated or unusual, and in all cases to give as clear and unbiassed a description as I could, so as to preserve any information the section might contain, for the benefit and use of future geologists. But, while thus describing the sections in their entirety, I aimed in each case to give prominence to some particular member of the section, generally selecting the feature which was best developed, and by this method I hoped in time to compass the whole of the drifts, and supply full details regarding every part of them.

In pursuance of this plan, I described in Part I., published in the Proceedings for 1881,* the cliff-section opposite the Alexandra Hotel, now concealed by a sea-wall, and dealt in that paper principally with the cause of the curiously ragged junction of the Purple Boulder-clay with the overlying gravels. In Part II., published in the

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* Proc. Yorksh. Geol. and Polyt. Soc.,' N.S. vii., p. 383.

Proceedings for 1882,* I particularized the cliff-section lying to the southward of the harbour, also now in part concealed, and discussed at length the Purple Boulder-clay, and its zone of stratification with associated sand and gravel. In Part III., published in the Proceedings for 1883,† I described the sections revealed during the drainage of the town, and, in my concluding notes, while to a certain extent summarizing the results of the previous papers, I sought chiefly to elucidate the beds lying above the Boulder-clays. These I supposed to be all of fresh-water origin, and, in speculating on the mode of their formation, I incidentally suggested a theory to account for the presence of deep valleys of erosion in the now-dry Chalk Wolds, which has since been greatly strengthened by fresh evidence.

In the present communication I purpose to describe the interesting cliff section, exposed for a short time through the breaking away of the sea-wall protecting the "Beaconsfield Estate" at Bridlington Quay, which is now again hidden by a new and more substantial erection. This section is conterminous on the north with that shown in fig. 1 of Part I., the two uniting at the ravine known as "Sands Cut." In this instance the most striking feature of the section is the unusually fine development of the "Basement Clay," which I shall therefore make the centre-piece of the paper.

The Section.—The length of the section is 235 yards, and its average height a little over 30 feet. Before the new wall was built the sea had removed nearly every trace of the old structure, and the cliff was everywhere fully exposed except for a few yards near its northern termination, where the higher portion was obscured by ruins of the Skating Rink.

Glacial Boulder-clays and gravels made up the whole of the section except towards the northern end, where there was a thin alluvial wash (1 of fig. 1) at the surface. The Boulder-clay was split up into three well-marked divisions, corresponding to the "Upper and Lower Purple" and "Basement" Clays of my previous papers; and in one or two places there was also a tendency for the top division to admit a sand-and-gravel-parting so as to separate off an upper portion, corresponding to what is known as the "Hessle Clay," in sections further south. Between the Basement and Lower Purple Clays there was in some parts of this section no intercalary bed whatever, and in others, a very thin wash of sand and gravel (4b.) ; but the division was in all cases sharply and distinctly marked by differences of colour and texture. Between the Lower and Upper Purple Clays there was a seam of clean-washed sand and gravel (3c.) varying in thickness from a mere trace to six feet. This gravel corresponds to the similar bed (2a.) shown in fig. 2 of Part I., and is probably on the same horizon as the "stratified band" (3c.) in the Purple Clay of the South Sands, as described in Part II. (fig. 1.) If it were very closely searched, waterworn crumbs of shelly matter could be collected from it ; but these fragments were so small and so rare that I do not think they were any proof of marine conditions during the formation of the seam.

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* **Proc. Yorksh. Geol. and Polyt. Soc., N.S. viii., p. 27.**

† **Ibid, vol. viii., p. 240.**

The Boulder-clays above the Basement Clay possess most of their characters in common, and are all of the type of the "Purple Clay," which has been fully described in my previous papers. They are stiff brownish or purplish clays, with a not very numerous sprinkling of angular, sub-angular, and rounded stones. In the lower band sporadic fragments of shells occur, of the same species as those found in the Basement Clay.

The various beds of this section lay comparatively regularly, and showed few signs of the confusion that existed in the adjoining cliff, where, as shown in Part I., the clays and gravels were almost inextricably entangled. The interposition of Sands Cut ravine, and the obscured ground bordering it, has prevented clear observation of the commencement of these disturbances, but, as pointed out in the conclusion to Part I., these movements probably took place during the formation of the 'Sewerby Gravels,' which are absent from this section. This absence of stratified beds above the Boulder-clay, and the correspondingly greater development of the clays, are the chief points of difference between our section and those illustrated in my former papers, Parts I. and II. This difference is not, I think, due to erosion, though erosion, acting upon a ready-made feature, may have accentuated it.

The central parts of the town of Bridlington Quay stand on a boss or ridge of Boulder-clay, which is bordered on the north and south by late-glacial or post-glacial gravels, as will be at once seen on referring to the coloured map attached to Part III. of this series. An examination of the same map will also show that this ridge of Boulder-clay is an almost direct prolongation on a lower level of the high chalk feature known as Bessingby Hill, which forms the south slope of the valley of the Gypsey Race, their continuity being broken only by a narrow spread of stream-gravel laid down by the Gypsey in comparatively recent times, and the Boulder-clay below it being as the drainage sections showed, close to the surface. When we remember the faithful manner in which Boulder-clays so frequently reproduce inequalities of the pre-glacial surface, these facts suggest that the ridge of clay in question, which is cut half across by the section we are discussing, is moulded upon a direct east and west prolongation of the chalk ridge, and that, were the drifts removed, the chalk would be found much nearer the surface at this place than on either side, a probability worthy the attention of well-borers. And if this be so, we may find therein additional proof, not indeed needed, that the Gypsey Valley (the 'Main Wold Valley' of the interior) is cut lower than the present sea-level, and that a hidden portion of this valley probably exists between our section and the appearance of the chalk in the cliff at Sewerby.

THE BASEMENT CLAY.

History and Bibliography.—Before entering into details with respect to this clay, to which, as I have already stated, it is my intention to devote the chief portion of this paper, I think it will be profitable to consider the origin and use of this term as applied to our Yorkshire sections. Setting aside numerous prior references to 'Upper' and 'Lower' Boulder-clays in Yorkshire, the term 'Basement Clay' seems to have been first used by Messrs. Wood and Rome, who in 1868, in their paper "On the Glacial and Post-glacial Structure of Yorkshire and Lincolnshire" (Quart. Journ. Geol. Soc., xxiv., p. 147), describe under this name "a lead-coloured clay abounding in chalk-débris and accompanied by stones and boulders from all sorts of rocks." Their figured section shows this clay at the cliff-foot from Kilnsea, near Spurn, to Dimlington, and again from Sand-le-mere, about four miles north of Withernsea, continuously to Hornsea, but not beyond, and these are the only places where the bed is recognized by them. Later researches, however, have made it evident that the horizon which Messrs. Wood and Rome followed between Withernsea and Hornsea is not identical with that traced at Dimlington, and that if we recognize in the latter the top of the true 'Basement Clay,' then we must regard the former as pertaining to a higher horizon, and forming the lower portion of the division, elsewhere classed as 'Lower Purple Clay.' In 1870, Mr. S. V. Wood, in a paper dealing chiefly with the Purple Boulder-clay (Quart. Journ. Geol. Soc., xxvi., p. 90), refers again to the Basement Clay in terms which show that he still confused it with the 'Lower Purple Clay.' He describes it as a clay 'full of chalk,' and frequently applies to it the name 'Chalky Clay' as a distinctive title, whereas, in the Basement Clay at Dimlington there is less chalk than in some other parts of the section. Indeed, it is quite clear that in this paper it is to what we have since called the 'Lower Purple' that the term Basement Clay is applied.

In 1878, and again, more clearly, in 1881, in papers describing the mode of occurrence of the so-called 'Bridlington Crag,' I showed (Geol. Mag., dec. ii., vol. v., p. 509, and dec. ii., vol. viii., p. 535) that the same clay which formed the base of the cliff at Dimlington, which I supposed to be the 'Basement Clay' of Messrs. Wood and Rome, was undoubtedly also present at Bridlington, and that the chief characteristic of the bed in both localities was to be found in its inclusion, among other foreign masses, of patches of fossiliferous sand and clay which formed the well-known shell-beds. In 1879, in describing to this Society the Drift Deposits of Filey Bay (Proc. Yorks. Geol. and Polyt. Soc., vol. vii., p. 167), I identified the Basement Clay, for the first time north of Flamborough. in an exposure on the shore, opposite to the village of Reighton, finding there also streaks of shell-bearing clay included in it. Again, in 1880, in a paper published in these Proceedings (vol. vii., p. 246), I suggested that the Basement Clay probably existed on Flamborough Head near the Lighthouses.

In the same year there was published Part I of an important memoir by Mr. S. V. Wood, "On the Newer Pliocene Period in

England," wherein a new scheme of classification of the drifts is propounded (Q. J. G. S., vol. xxxvi., p. 457), and the Basement Clay of Holderness appears to be considered as the equivalent of the Cromer Till (a correlation which though it cannot be looked upon as in any way proved, yet seems to me the most probable one yet suggested). In this paper the author also seems inclined to recognize an equivalent of the Basement Clay in the lowest clay of Filey and the region to the northward. In 1882, in Part II., op. cit. vol. xxxviii. p. 667, of the above-mentioned memoir, Mr. Wood puts forward still more distinctly this correlation of the Basement Clay with the Cromer Till, and also the view that this clay may extend along the coast northward from Flamborough, though it is still argued that the shell-beds at Bridlington and Dimlington are in place, and that the molluscs lived where they now occur.

In 1884 I submitted (Quart. Jour. Geol. Soc., vol. xl., p. 312) an account of an exposure close to Bridlington Quay, immediately south of the section now described of the Basement Clay, with an unusually large proportion of shelly inclusions, whereby the list of species known from the deposit was raised to over 100 by the addition of 42 species not previously recorded, five of these being new to science.

In 1885 our knowledge of the Drift Deposits of Holderness was for the first time put upon a satisfactory basis by the publication of the Survey Memoir, written by Mr. Clement Reid (Mem. Geol. Survey; The Geology of Holderness). In this work the limits of the different divisions of clay are clearly marked out, and a particularly full description is given of the Basement Clay and its associated deposits, especially as regards their development in the neighbourhood of Dimlington. The fragmental and transported character of the shell-beds is fully recognized, and lists of the fossils are given. It is also pointed out that difficulties exist in believing that the Basement Clay thins out against the chalk-slope north of Bridlington as we had generally supposed.

Finally, last year, in a report to the British Association (On an Ancient Sea-beach at Sewerby, Rep. Brit. Ass. 1888, p. 328), and also in another quarter (Congrës Géologique: Explications des Excursions, p. 164) I mentioned that I had at length been able to trace clearly the northward extension of the Basement Clay over the fossiliferous Sewerby Cliff-beds, and thence over the solid chalk : a point which it will be my aim to elucidate still further in the sequel.

We thus find that the term "Basement Clay," first applied by Messrs. Wood and Rome, apparently as a descriptive title, is not now used in exactly the same manner as by those authors, but is more conveniently restricted to a dark earthy boulder-clay with shelly inclusions typically developed at Dimlington and Bridlington, but of whose extension in the interval between these two localities we have no evidence, though it may be supposed with probability to underlie this interval at a lower level than the base of the cliff. As thus defined it can no longer be described as a chalky clay, as it contains considerably less chalk than does the clay immediately overlying it in Southern Holderness, with which it has been confounded, and from which it appears to be quite distinct. This must be borne in mind in studying Messrs. Wood and Rome's or Mr. S. V. Wood's descriptions. It is not yet proved with what degree of accuracy we may call this clay the *basement* bed, since there is a considerable thickness of drifts below the sea-level in Holderness of which we know nothing; but my recent researches have led me to think that though glacial conditions may have prevailed long before the formation of this bed, it was yet the earliest boulder-clay deposited in the area. This part of our subject will be discussed at length in the concluding "notes."

Description of the Clay.—We may now enter upon the study of the Basement Clay, as developed in our section. It was here, as usual, very heterogeneous in character, and consisted of a mixture, more or less intimate, of greenish, earthy Boulder-clay, with pockets, streaks, and patches of sand, earthy gravel, or tough clay. Most of these inclusions were unfossiliferous, but a few contained marine remains, and might therefore be considered as forming portions of the "Bridlington Crag." These are marked 5c. in the section, fig. 1. Though none of these fossiliferous patches attained the size of those which are occasionally exposed on the shore just beyond the southern limits of our section (described by me in Quart. Journ. Geol. Soc., xl., p. 314), they were yet large enough to contain a numerous fauna, which, however, did not reveal itself to the surface-collector, and yielded only to the drastic methods* adopted by that indefatigable and experienced worker, Mr. W. B. Headley, who took advantage of the occasion to secure three or four tons of the most promising material, so as to be able to deal with it at leisure. From that portion which he has already sifted, he has obtained many hundreds of specimens (which have been most considerately placed at my disposal in working out the fauna), and it is more than probable that among this material we shall find some species new to the list.

The curiously unequal distribution of the species noticed in my previous papers, was strikingly evident in these beds. Thus, several fine unbroken valves of *Pentunculus glycimeris* were taken from a small pocket of coarsish sand near the third break-water, and in no other part of the section was this shell found ; and again, while the large patch near the site of the old skating rink (B of section) contained a large and varied fauna, and proved the richest part of the deposit, there was a mass exposed on the fore-shore just opposite and not many yards away, composed almost entirely of large valves of *Cyprina islandica* crushed into angular fragments.

The Boulder-clay itself also contained many shell fragments. *Tellina balthica* being the most abundant, as it generally is in the Boulder-clay, though this species was not found in any of the patches. A list of the molluscan fauna of these beds, partly compiled from previous work, is given in Appendix A, p. 294. Large numbers of Ostracoda and Foraminifera were also noticed, but have not been determined. They were probably of the species recorded in Reid's Holderness, p. 22-23, and my paper, Q. J. G. S., xl., p. 323-326.

This tendency of the Basement Clay to include patches of other deposits I regard, as mentioned above, as one of its chief characteristics, and it is a feature which distinguishes it from the Purple Clay. The inclusions are not always beds of glacial age, but are sometimes derived from the secondary formations, masses of Liassic shale and Neocomian clay occurring, the former, among other places, in Filey Bay,* and at Bridlington,† and the latter at several places on Flamborough Head.‡ The conditions under which these masses of the older formations are found exactly parallel, the occurrence of the shell bearing patches, the original bedding being sheared and shaken, but not obliterated, the fossils being preserved, though generally fractured, and each mass forming an isolated 'boulder' in the clay. Some of them, we know, must have travelled no inconsiderable distance, as, for instance, the patches of Lower Lias at Filey and Bridlington, which cannot have journeyed for less than several miles, even if we allow that strata of this age may crop out in the bed of of the North Sea, nearer than on the coast line.

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* The method usually followed by Mr. Headley is to break up the sandy and clayey material into pieces about the size of a walnut, detecting in this stage the larger specimens, and then after thoroughly drying and baking the lumps in the oven to plunge them while still hot into cold water. Under this treatment the material falls into an impalpable mud, and may easily be passed through a fine-meshed sieve, so as to separate out all the smaller shells and shell-fragments, along with water-worn pebbles, spines of echinoderms, teeth of fish, and other odds and ends that gather on a sea-bottom.

With such distinct proof of transportation from a distance in some cases, we can scarcely resist the conclusion that in others also, though the evidence is less decisive, the beds are likewise far from their original positions, especially in the case of the shelly patches, which possess characters showing that they can hardly have been formed in the neighbourhood in which we find them. It has indeed been suggested that the shelly patches may be remnants of beds which occur in places lower in the section, but we found nothing to support this view in the boring on the foreshore, presently to be described, and it is still more strongly negatived by the evidence of the shell-bed recently discovered at the South Sea Landing, where the whole of the drift series resting on solid chalk is exposed in section, and where there is not the slightest trace of fossils, nor even of marine action of any kind, in the stratified beds below the Basement Clay.

Thickness and Extent of the Basement Clay.—So long as the only places where the Basement Clay could be studied were the limited sections of Bridlington and Dimlington, we were unable to prove whether its peculiarities were persistent and worthy of being made the basis of a division, or whether they were nothing more than local characters developed incidentally in the mass of drift deposits which cover Holderness. Indeed there is no doubt that it is essentially liable to great local changes, and that these changes are often of a perplexing nature ; but recent researches have satisfied me that its chief characteristics, its earthy or sandy texture, its distinctive greenish or bluish colour, and its irregular composition, are preserved over wide areas, and are sufficiently marked to warrant its separation from the higher clays, and to demand special explanation.

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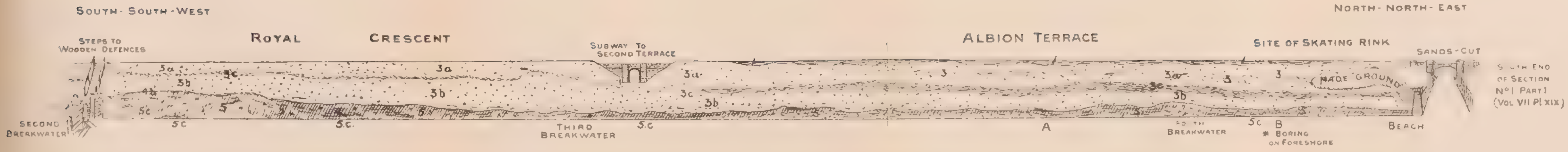
* Quart. Journ. Geol. Soc., vol. xlv., p. 580.

† Phillips' Geology of Yorkshire, 3rd ed., p. 85, and Rep. Br. Assoc. 1874, p. 84.

‡ Proc. Yorksh. Geol. and Polyt. Soc , N.S., vol. vii., p. 244.

With regard to its thickness in our section there was 15 feet of it in the cliff near the southern extremity, and the engineer for the sea-wall informed me that its base was not reached at this place in a boring of twenty feet below the cliff-foot. At the northern end, however, there was not more than four or five feet in the cliff, and here, fortunately, I am able to give exact information, as we tested its thickness during our investigation of the Sewerby Cliff Beds last year by means of the boring-rods of the Geological Survey, which were most considerately placed at our disposal. We selected a spot on the foreshore where the clay happened to be conveniently exposed (marked by an*, fig. 1), and there sunk through 22 feet of dark Boulder-clay with a few silty streaks, and reached at that depth fine chalky rubble or gravel yielding a little water, into which we bored for three feet further. This chalky stuff resembled that seen below the Boulder-clay in the cliff-foot near Sewerby, whence we traced it by means of the rods for some distance in the direction of our section. There is, therefore, every probability that it was the same bed, and that we had reached the base of the clay in our boring, and we may, therefore, conclude that at this place the clay has a total thickness of about 30 feet, and that it rests on the same chalk-rubble seen further to the eastward. Above it, as already mentioned, there is here little or no intercalary material between it and the Lower Purple Clay, but the junction is nevertheless so clear and decided that a knife might be inserted on the plane of separation. But both north and south of Bridlington Quay, as soon as the Basement Clay sinks below sea-level, we find stratified beds making their appearance at this horizon, consisting, as shown in my previous papers (Pt. I., fig. 2, and Part II., fig. 1), of a thickish bed of finely-



Scale: 1 in. = 60 ft.

Explanation.

1. Alluvial Wash.
3*a*. "Upper Purple," Boulder Clay.
3, 3*c*. Sand and Gravel.
3*b*. "Lower Purple" Boulder Clay.
4*b*. Thin irregular seam of Clayey Sand and Gravel.
5. "Basement" Boulder Clay, with many included pockets and patches of Sand and Clay, of which those marked 5*c* contained Marine Shells (*Bridlington Crag*).

*Position of Boring on the foreshore described in the text (p. 284); bottom of Basement Clay reached at 24 feet, and Boring carried 3 feet further through fine chalky Gravel.

N.B.—The numbers are applied as in Part I., Fig. I., except in the case of 3*c* which probably corresponds to 2*a* of that section.

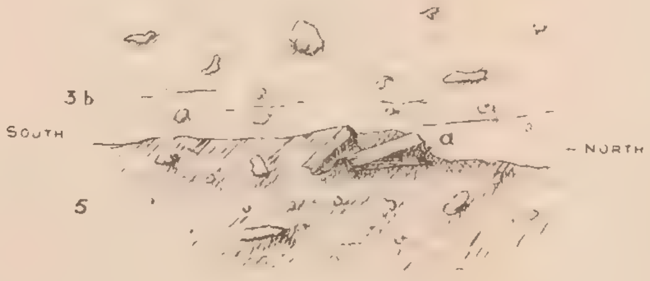


Fig. 2. Enlarged to show the Junction of the Purple and Basement Clays at A.

Fig. 2, an Angular Boulder of close-grained sandstone (*a*) with well-marked bedding planes, lying embedded in the surface-layer of the Basement Clay (5) has been split in two and the fragments forced apart. The Sandstone Slab is about 4 inches long by 3 inches broad, and each portion 1 inch in thickness.

Lamplugh: Glacial Sections near Bridlington: Cliff opposite the Beaconsfield Estate.

laminated elastic clay of a brown colour, without stones, surmounted in places by a bed of sand. At Dimlington also stratified beds are often developed at this horizon.

In tracing the Basement Clay southward from Bridlington Quay, we find that in less than a mile its upper surface, following no doubt the slope of the chalk, sinks below low-water mark, and does not reappear. In going northward, the sections are extremely difficult to study, and it is only quite recently that I have been able to trace the clay. Indeed the section between the outskirts of the town and the place where the chalk suddenly appears in the cliff at Sewerby, a distance of under half-a-mile, has always been to me the greatest stumbling-block in the study of the Yorkshire Drifts. Along this bit of coast erosion proceeds very slowly, probably owing to the close proximity of the sheltering headland, and consequently the cliffs, being high and formed of loose and incoherent material, weather down into long slopes, so that the structure of their lower portion is quite obscured, and not until the vertical cliffs of chalk are reached is there usually any opportunity for seeing clear sections of the drift. But it is precisely in this hidden interval that the junction is made between the drifts of Flamborough and those of Holderness, and so perplexing are the changes which occur in this short space, that until they were unravelled, it was not possible to identify with any degree of certainty the drifts lying above the chalk cliffs with those at the lower levels. At Bridlington, as just described, there are at least three boulder-clays, and these there is no difficulty in correlating with the Holderness deposits; but above the chalk at Sewerby only two divisions can be traced, and, though further eastward these again split up, it has been impossible to say what divisions are represented. Searles V. Wood, as we have seen, first placed the whole with the Purple Clay, and other writers followed his opinion. In his latest paper, however, he seemed to admit the Basement Clay into these sections; but, apparently, no new evidence had been acquired, and the grounds on which it was now recognized were as unsatisfactory as those on which he had previously based its exclusion. But last year, thanks partly to our borings and excavations into the Buried Cliff Beds, and still more to a stormy sea and high tide, which stripped away the shingle off the shore, and washed a clear section at the base of the cliff (too soon again obscured), I was able to carry the lines across this region of difficulties, and to emerge with them clear on the other side where it is comparatively easy-going. As I now read the section in this space the Upper and Lower divisions of the Purple Clay come together, owing to the fading out of the intermediate gravel, and these form the Upper Clay at Sewerby. The laminated clay below the Purple Clay thins out or passes into a contorted mixture of chalky gravel and stratified Boulder-clay, and the Basement, with some local change in character, and especially in the nature of its inclusions, which become chiefly sub-angular, chalky rubble rises into the cliff foot as we approach Sewerby, and finally mounts to the top of the chalk by a long slope, whereon it is seen to over-ride, and partly to inosculate with the thick chalk-rubble which lies over the Buried Cliff-beds and over the solid chalk ; and it is clear now that the lowest Boulder-clay between Sewerby and Danes Dyke, seen in section, at heights varying from 30 to 80 feet above sea level, is the Basement Clay. At Danes Dyke, the cliff intersects a pre-glacial valley, which has been filled in with a great accumulation of glacial sand and gravel, and afterwards partly re-excavated, a feature observable at several other places on the headland. On the west side of this valley the Boulder-clays thin away into narrow bands, and the greater part of the drift consists of gravels, some chalky, and others chalkless, or nearly so, but on the east side we are able again to recognize the Basement Clay, and to follow it without interruption for another mile, to the South Sea Landing, where again the phenomenon of a buried pre-glacial valley presents itself. The section at this point becomes very complicated and difficult to correlate, but the opportune discovery last summer of a seam of greenish sand with glacial shells in a band of Boulder-clay on the further side of the hollow, not only yielded the needed clue, but confirmed beyond doubt the presence of the Basement Clay in these cliffs. The fossiliferous sand occurs as a narrow contorted streak, surrounded by a few inches of fine plastic clay, in which the original bedding is nearly obliterated by the numerous planes of shearing, the whole being embedded in a narrow band, at this point six feet thick, of stoney Boulder-clay, which thickens considerably in one direction, and passes into the normal lower Boulder-clay, and in the other tapers away and disappears between stratified beds. It is most instructive to find that in this, the only instance in which we have been able to study the shell-bearing patches in full section, and to see the base of the drifts below, that though there are stratified beds lower in the series these are quite different in character from the fossiliferous sand, contain no fossils, and are probably not of marine origin, thus lending no countenance to the view that the shelly patches have been derived from beds immediately underlying the Boulder-clay. A full description of this interesting section will be found in a recent number of the Geological Magazine.

From the South Sea Landing the Basement Clay may be followed eastward almost step by step to the Lighthouses at the most easterly point, where it is largely made up of the débris of the Speeton Clay,* sometimes indeed without other admixture, and thence, turning westward we trace it, with curious local aberrations, through the buried valleys of the North Sea Landing and Thornwick Bay. Beyond Thornwick, however, when we reach the rising ground which leads to the high cliffs of Bempton, Buckton, and Speeton, we find the lower clay grows thin and indefinite, with a constant tendency to pass into gravels, but on descending at Speeton there is little difficulty in again identifying it, and in following it northward across Filey Bay; and I believe that it extends, with some local interruptions, past Scarbro', Whitby, and Saltburn. I have not yet examined the sections lying north of the Tees. Thus we find that in most of the cliff sections of the Yorkshire Coast there is a bed with well-marked characteristics, which, though beds of glacial origin occasionally occur below it, is the lowest of the series which can be called a *boulder clay*; and this bed is therefore well-described by the term Basement Clay. Before giving the inferences to which I have been led in studying this clay, I will add a few notes on its contained boulders.

Boulders of the Basement Clay.—There are decidedly fewer *large* boulders in the Basement Clay than in the Purple, but the number of small stones is quite as great, and these present an extraordinary diversity. Besides fragments from nearly every stratified formation, there are innumerable igneous and metamorphic rocks which the skilled petrologist alone can determine. I made a large collection of these boulders from the present section and from that illustrated in Part II., and a list of the rocks identified within this limited area is given at the end of this paper (Appendix B). The list might have been almost indefinitely lengthened if it were possible for me to define accurately minor differences in the igneous rocks.

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* Proc. Yorksh. Geol. and Polyt. Soc., vol. vii., p. 244.

Fortunately through the kindness of Mr. A. Harker, M.A., F.G.S., Fellow of St. John's, Cambridge, I have been able to place a few of the most interesting specimens into thoroughly qualified hands; and in Mr. Harker's valuable notes which are appended to my paper (Appendix C), will be found exhaustive petrological descriptions of some of the selected fragments which have been sliced and examined microscopically. Mr. Harker indicates, as have all previous observers, a widely diverse origin for the pebbles, and thinks that, though not many of the rocks can be precisely localised, there are amongst them some probably from Scandinavia, others from the Cheviots, and others from the South and even perhaps from the West of Scotland. But as I shall presently show, these smaller pebbles though very interesting, are not safe guides to the actual direction of the ice-flow, and I think that the study of the *larger* boulders of the drifts on which I am at present engaged, and in which also I have received promises of invaluable aid from Mr. Harker, is more likely to yield information on this point. An instalment of this work will be found in the present volume of the Proceedings of this Society.

It remains now to give, as on former occasions, some inferences with regard to the Basement Clay to which I have been led by the study of the sections.

Notes and Inferences.—Nothing could be clearer than that the scrapings of a sea-bottom have been incorporated in the Basement Clay; and in these sections one may study almost every process in its manufacture. It is easy to recognize in the curved and contorted fragments of beds, which the Basement Clay contains, the raw material that went to the making of it, and one finds this material in every stage, from that on which its original structure and organic contents, if any, are preserved, to that in which all trace of its former condition is obliterated, and the substance is no longer distinguishable from the mass of the boulder-clay. These sections, indeed, present many examples of the boulder-clay in a state of arrested development, and in examining them we may follow the life-history, as it were, of that deposit. The raw material has clearly been most heterogeneous in character, and nothing has come amiss to the powerful engine which rolled out these clays. Sand, gravel or silt; clay, shale or solid rock; no matter of what age, whether old Secondaries scooped out of the North Sea floor, or contemporaneous morainic matter only just laid down in front of the advancing sheet, all alike passed into the mixer and were more or less completely reconstructed.

So far all is clear enough, but when I try to conceive how the soft shales and incoherent sandy beds came to be taken up from the sea bottom and transported, as most undoubtedly they have been, for long distances, difficulties arise, and I fail to reach a safe conclusion. Were the beds littoral, one might suppose that floating ice from the ice-foot assisted in the work by removing and carrying portions of the beach deposits to places in which they were afterwards overtaken and over-ridden by the steady forward-creeping land-ice ; but many of the shells indicate comparatively deep water, and may have come from almost anywhere in the bed of the southern part of the North Sea. Moreover, the evidence is distinctly in favour of the view that these incoherent masses became actually embedded in the ice, and rose with it to the higher levels, just as we know the solid boulders have sometimes done ; but how this was effected I cannot make out, unless we may imagine that 'anchor-ice' had formed and affixed itself to the sea bottom before the encroachment of the land-ice, with which it afterwards combined. But however the removal of the beds came about, the strong presumption that they were in some way or other actually embedded in the ice-sheet is a point which must not be lost sight of in studying the glacial gravels. These must have been derived in great part from the ablation of the ice, and if the ice contained marine shells we may be sure that traces of such shells would be found in the gravel formed from it, though laid down by fresh water at elevations far above sea-level.

It is well known how keen has been the discussion as to the origin of the high-level shelly drifts of Moel Tryfaen, Macclesfield, and other places, and if it can be shown that the ice which reached these places was charged, as that of East Yorkshire seems almost certainly to have been, with the spoils of a sea bottom, the explanation of the shelly drift will be simple enough.

Another feature which may be explained by the formation of the Boulder-clay from the bed of an Arctic sea is the above-mentioned extraordinary diversity of the boulders. As Reid has pointed out,* the gathering in of these boulders has evidently been a complex process. The presence in the Boulder-clay of well-rounded beach-pebbles, and of *Pholas*—and *Saxicava*—bored limestones proves that many of the erratics must have lain for some time on a sea-bottom, whither no doubt they were dropped in the first place by floating ice, for the fauna of the shell-beds, the character of their pebbles, and other signs are convincing evidence for the rigorous climate which prevailed during their formation. And before the land ice reached any given area of this sea-bottom, we may be sure it had been crossed and re-crossed by the floating ice with which the enclosed North Sea must have been cumbered. This floating ice, carried hither and thither by wind and tide, would scatter its burden at random, and cause a very miscellaneous accumulation even before the passage of the land-ice ; which, in turn, would intensify the diversity partly by the addition of new material, and partly by still further mingling the old. Wherefrom it follows that we must not place much confidence in the evidence gleaned from the erratics as to the actual direction and distance which the ice-sheet has traversed.

It has been for many years a favourite opinion of glacialists that our Yorkshire Drifts are, as a whole, newer than those of Norfolk and the Eastern Counties, the supposition being that the more southerly region, being nearer the periphery of the ice, preserves beds of older date than the area further north, wherein prolonged glaciation is supposed to have destroyed all the relics of the earlier stages. But I think there are no grounds for this assumption ; and although the later Tertiaries are wanting in Yorkshire the reason is that this area formed a land-surface during that period, and in the cliff sections we still possess a full record of the glacial period from its commencement to its close.

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* **Survey Memoirs, "Cromer," p. 90, "Holderness," p. 43.**

I will summarize the evidence which leads me to conclude that there was practically no glacial deposit in Eastern England before the formation of the Basement Clay. It needs no lengthy study of the drifts to discover that the chief work of the ice on the low ground was to spread out sheets of rudely stratified deposits, which lie, broadly speaking, conformable to one another ; and it is only on rare occasions that proof of any serious or wide-spread erosion presents itself. And I do not see on what grounds we can suppose that the earlier would differ from the later phases of glaciation in this characteristic, which is clearly one of the results of the physical geography of the region, and not therefore liable to alteration under similar conditions ; therefore if any wide-spread deposit of glacial age older than the Basement Clay had ever existed in this area, I am of opinion that we should most assuredly have discovered the proof of it. Instead of that we find that the ice which formed the Basement Clay almost certainly passed over a floor of bare Secondary Rocks, save where they carried a thin covering of marine beds, which were practically contemporaneous ; (for there are strong reasons for thinking that the shells of the fossiliferous beds were alive very shortly before their transportation). How otherwise can we explain the fragments of Secondaries which the ice has seized upon to aid in the formation of its basal-moraine. It cannot be urged in explanation that the transported Secondaries may have formed protuberant bosses projecting above the general level of a drift-covered surface for they are chiefly of shale and clay, which might form flat ground or hollows, but not, under ordinary denudation, hills or projections.

Another argument in favour of the early glacial age of the Basement Clay may be deduced from its close relationship to the chalk-rubble on Flamborough Head. This rubble, which appears to be of glacial origin, can only have been formed when the chalk lay uncovered and exposed, as it has probably never done since the beginning of the formation of boulder-clay in the locality. It is curious how persistent all over England and Scotland is this rubble of the local rock at the base of the drift series. The reason of the striking distinction which frequently occurs between it and the overlying glacial beds, especially with regard to the quantity of extraneous material they contain, is not very easy to explain when they are both regarded as *moraine-profonde*, and we have in this comparison one of the many, yet unexplained problems of glacial geology.

Again, on both sides of Flamborough Head, at Sewerby, and at Speeton we find the relics of marine beds below the Basement Clay and its associated chalk-rubble, that appear to have accumulated before there was any boulder-clay existing in the neighbourhood, (the few drift pebbles in the old beach at Sewerby I regard as the product of drifting ice), and these prove an open sea, a shore-line, and a land-surface tenanted by numerous large mammals, such as the elephant, rhinoceros, hippopotamus, bison, etc., at a period not long anterior to the formation of the Basement Clay, the relative level of land and sea not being very different from what we find at present.

It may be urged that we could hardly expect that the first deposit of the age would be a bed containing proof of such extreme glacial conditions as the Basement Clay. But I believe that a careful study of the physical geography of the region will dispose of this objection, by showing that the area was incapable of initiating for itself a system of glaciation, and consequently remained practically unglaciated until the arrival upon the coast of the great mass which had crept on slowly from the north and east. However, this is a point which I reserve for further discussion upon a future occasion.

If we can indeed satisfactorily establish that the Basement Clay and its associated beds have been the first deposit of the glacial period in East Yorkshire, we shall have materially simplified the study of that period in Eastern England. We could then accept the Speeton Estuarine Shell-bed and the Sewerby Buried Cliff-beds as pre- or early glacial *(sub-glacial)*, and compare them with beds found at similar levels and under somewhat similar conditions below the drifts of Norfolk, while in the Basement Clay itself we should recognize the equivalent of the Cromer Till. But more work must be done before we can place any such correlation on a really satisfactory basis, and it is first especially necessary to find out what relationship exists between the upper members of the series in the two regions.

Another point worthy of attention in our section is the great irregularity of the upper surface of the Basement Clay and the absence of the stratified bed seen to overlie it in the cliffs to the north and to the south. The question arises whether this is due to unequal deposition or to erosion, and to this question it is difficult to give a decisive answer, though I think the evidence favours the view of unequal deposition. The shearing of the cracked boulder at the top of the Basement Clay, shown in fig. 2, indicates that there has been sliding pressure applied to the surface of the bed such as might well effect erosion, and the character of its junction with the Purple Clay in the adjoining section (see fig. 1, Part I.) seems to show a considerable disruption of its surface, so that stratified beds may have existed and have been afterwards removed. But on the other hand the Laminated Clay seems always to have been a low-level deposit, for on neither side of the town does it rise above the level of the highest tides, and when favourable circumstances enabled me to trace it towards Sewerby, it appeared to pass into chalky gravel and stratified stoney boulder-clay when it left the beach. It cannot, therefore, be used as evidence of wide-spread aqueous denudation and deposition at this period. The Yorkshire Boulder-clays were evidently deposited very unequally, being piled up in one place and scarcely developed at all in another, and they must have been left with an extremely irregular and uneven surface. This has no doubt in some cases been intensified by later erosion, but the drainage of Holderness since the glacial period has been so sluggish that the erosive work performed by it cannot have been great.

Whether it be believed that the Basement Clay is the product of land-ice or of floating-ice, it is very evident that in either case the current which deposited it came down from the northward or north-east. On the north side of Flambro' Head, as shown by certain very interesting surface-contortions in the chalk near Selwicks Bay, its course seems to have been from almost due north ; but on the south side it may in places have been from nearly due east, and at Bridlington Quay from the north-east. In studying the drifts of the headland

I have been greatly impressed by the effect which the cliffs of the northern side (about 400 feet high) have had in diverting the ice-current. It is clear that during the greater part of the glacial period the ice in this locality, though it seems to have slightly over-topped these cliffs, was certainly not thick enough to over-ride them; consequently it is very improbable that the Wolds were ever covered, and indeed I think that I have accumulated sufficient evidence, to be made use of hereafter, to prove that they were not.

APPENDIX A.[1]

LIST OF SHELLS FROM THE BASEMENT BOULDER-CLAY, AND ITS INCLUDED MASSES OF SAND AND CLAY AT BRIDLINGTON QUAY AND FLAMBOROUGH SOUTH LANDING.

NOTE.—Shells marked thus †, mentioned in previous lists have not yet come under my own observation. The following signs indicate the relative abundance of the shells at Bridlington. *v c.*, very common; *c*, common; *r.*, rare; *v.r.*, very rare. Species marked ‖ occurred chiefly, if not solely, in the sandy seam near the third breakwater. Species not now living are distinguished by two asterisks, thus **.

		Bridlington Quay.	Flambro' South Landing.
	BRACHIOPODA.		
v.r.	Rhynchonella psittacea, Chemnitz.	*	
	CONCHIFERA.		
c.	Anomia ephippium, Lin.	*	
c.	*var.* aculeata	*	
r.	*var.* squamula	*	
c.	Pecten islandicus, Miller.	*	*
v.r.	pes lutræ, L.	*	
‖ *c.*	opercularis, L.	*	
r.	Mytilus edulis, L.	*	
‖ *c.*	modiolus, L.	*	?
v.r.	Crenella decussata, Mont.	*	
v.r.	Leda minuta, Müll.	*	
v.r.	*var.* buccata	*	
v.r.	Leda tenuis, Philippi	*	
r.	lenticula, Möll.	*	
c.	limatula, Say.	*	?
c.	intermedia, M. Sars.	*	
v.r.	pernula, Müll.	*	
c.	Nucula Cobboldiæ, Leathes	‡*	

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[1] Note.—The Bridlington list is based chiefly on the catalogues given by Dr. J. Gwyn Jeffreys in Phillip's Geol. of Yorksh., 3rd ed., p. 274, and in the appendix to my paper in Quart. Journ. Geol. Soc. xl., p. 319; and by Clement Reid in Survey Mem. "Holderness," p. 23.

		Bridlington Quay.	Flambro' South Landing.
	CONCHIFERA.		
v.r.	Nucula nucleus, L.	*	
	† tenuis, Mont.	*	
	† *var.* inflata	*	
‖ *c.*	Pectunculus glycymeris, L.	*	
c.	Montacuta Dawsoni. Jeff.	*	
v.r.	Axinopsis orbiculata, G. O. Sars.	*	
r.	Cardium groenlandicum, Ch.	*	*
c.	islandicum, L.	*	
‖ *c.*	edule, L.	*	
c.	Cardita borealis, Conrad.	*	
v c.	Cyprina islandica, L.	*	*
c.	Astarte sulcata, Da Costa	*	*
e.	*var.* elliptica	*	
v.c,	borealis, Ch.	*	*
c.	*var.* mutabile	*	
r.	*var.* Withami	*	
v.c.	compressa, Mont.	*	*
v.c.	*var.* striata	*	*
	† depressa,[1] Brown	*	
	†Venus fluctuosa, Gould	*	
v.r.	ovata, Tennant	*	
v.c. *in Boulder Clay.*	Tellina balthica, L.	*	
c.	calcaria, Ch.	*	
r.	obliqua,[2] J. Sow.	‡*	
v.r.	pusilla, Phillippi	*	
	†Donax vittatus, Da. C.	*	
‖ *c.*	Mactra solida, L. *var.* elliptica	*	
‖ *v.r.*	Solen ensis, L.	*	
c.	Corbula gibba, Olivi	*	
v.r.	pusilla, Phillippi	*	
	†Thracia prœtenuis, Pult.	*	
	pubescens,[3] Pult.	*	
v.c.	Mya truncata, L.	*	*
c.	*var.* uddevallensis	*	*
	† arenaria, L.	*	
v.c.	Saxicava norvegica, Spengler	*	*
v.c.	rugosa, L.	*	*
v.c.	Pholas crispata, L.	*	
	SOLENOCONCHIA.		
‖ *c.*	Dentalium entalis, L.	*	
c.	striolatum, Stimpson	*	*
	GASTROPODA.		
v.r.	Lepeta cœca, Müll	*	
r.	Puncturella noachina, L.	*	
v.c.	Trochus varicosus, M. & A.	*	

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[1] I have found this shell at Dimlington, but not yet at Bridlington.

[2] It is disputed whether *Nucula Cobboldiœ* and *Tellina obliqua* are extinct or not.

[3] I have found this shell at Dimlington only.

	GASTROPODA.	Bridlington Quay.	Flambro' South Landing.
r.	Trochus cinereus, Couth.	*	
v.r.	cinerarius, L.	*	
‖ *v.r.*	zizyphinus, L.	*	
v r.	Grœnlandicus, Ch.	*	
c.	Lacuna divaricata, Fabr.	*	
	crassior[1] Mont.	*	
r.	Littorina obtusata, L.	*	
r.	*var.*	*	
r	globosa, Jeffr.	**	
r.	rudis, Maton	*	
r.	litorea, L.	*	
r.	Rissoa subperforata,[2] Jeffr.	**	
c.	Wyville-Thomsoni, Jeffr.	*	
r.	*var.*	*	
r.	parva, Da-Costa	*	
r.	*var.* interrupta	*	
r.	striata, Ad.	*	
	†Turritella terebra, L.	*	
v.c.	erosa, Couth.	*	*
r.	Scalaria grœnlandica, Ch.	*	
v.r.	Odostomia conspicua, Alder.	*	
c.	Natica groenlandica, Beck	*	
v.c.	islandica, Gm.	*	*
v.c.	affinis, Gm.	*	
c,	*var.* occlusa	*	
	† Montacuti, Forbes	*	
r.	Amaura sulcosa, Leche	*	
c.	Menestho albula, Fabr.	*	
v.r.	Trichotropis borealis, Brod. and Sow.	*	
r.	Purpura lapillus, L.	*	
c.	Buccinum undatum, L.	*	
r.	groenlandicum, Ch.	*	
c.	Trophon clathratus, L.	*	
r.	*var* Gunneri	*	
r.	*var.* truncata	*	
	† Fabricii, Beck	*	
	† latericeus, Müll	*	
c.	Fusus despectus, L.	*	*
c.	curtus, Jeffr.	*	
	var. expansa	*	
c.	Kroyeri, Möll.	*	
	† Leckenbyi, S. V. Wood	*	
	† spitzbergensis,[3] Reeve	*	
	† propinquus, Alder.	*	
r.	Sarsi, Jeffr.	*	

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[1] Dr. Jeffreys also recognized *Lacuna crassior* among Mr. Headley's specimens but, either purposely or inadvertently, did not incorporate the species with his list. Recent specimens have, however, confirmed the determination.

[2] *Rissoa costata*, Adams, and *Rissoa semistriata*, Mont., also occur in Mr. Headley's collection, but as the specimens were obtained from beds between tide-marks, and these small shells abound on the present beach, they must be considered as "doubtful" species, and I have omitted them from the list.

[3] I have found this shell at Dimlington only.

		Bridlington Quay.	Flambro' South Landing.
	GASTROPODA.		
v.c.	Admete viridula, Fabr.	*	*
	†Columbella rosacea, Gould	*	
v.c.	Pleurotoma turricula. Mont.	*	
c.	*var.*	*	
r.	exarata, Möll.	*	
c.	decussata, Couth.	*	
r.	*var.*	*	
v.r.	simplex, Midd.	*	
r.	multistriata, Jeff.	**	
c.	bicarinata, Couth.	*	
r.	*var.* violacea	*	
r.	elegans, Möll.	*	
	† harpularia, Couth	*	
r.	pyramidalis. Str.	*	
r.	Trevelyana, Turt.	*	
r.	Cylichna alba, Brown	*	
v.r.	scalpta,[1] Lech	*	
r.	Utriculus obtusus. *Mont. var.* pretenuis	*	
v.r.	constrictus. Jeffr.	**	
v.r.	Bulla crebristriata, Jeffr.	**	

For lists of the Foraminifera, Cirripedia, Entomostraca and Vertebrata, see Reid's "Holderness," pp. 22-26, and my paper in Quart. Journ. Geol. Soc. xl., pp. 322-326.

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[1] Dr. O. Torell, Director of the Swedish Geological Survey, a well-known authority on arctic mollusca, examined Mr. Headley's collection when at Bridlington two years ago, and pointed out the misprint in former lists of the specific name of *Cylichna* (*Bulla*) *sculpta*, which should read *Cylichna scalpta*. He thought it probable that the species figured as new by Dr. J. G. Jeffreys, under the title *Utriculus constrictus*, might belong to a previously-known species from arctic waters, and that there was another species of Astarte present in the collection. He laid considerable stress on the absence of *Leda arctica* from these beds, as showing that the climate during their deposition was not so extreme as it was when the Clyde Beds, and other deposits containing that shell, were formed. While mentioning this species I may add that on examining the specimens which I collected at Esquimault Harbour, Vancouver Island, Dr. Torrell declared that the determination which I obtained of one of the shells as *Leda arctica* was incorrect, and that the specimen did *not* belong to that species, which should not therefore have appeared in my list in Quart. Journ. Geol. Soc, vol. xlii, p. 280.

APPENDIX B.

A LIST OF BOULDERS FROM THE BASEMENT BOULDER CLAY AT BRIDLINGTON QUAY.*

NOTE.—The Boulders vary in size from pebbles to blocks of several feet in diameter. *c.* common. *r.* rare.

IGNEOUS ROCKS.†

c. Granite of several distinct types, generally pink, gray, or dark-coloured.
Biotite-granite,
Hornblende-granite, and
Syenite of several kinds, including
Augite-syenite.
Andesite.

c. Porphyritic felstone,
Felsite, and
Quartz-Felsite.
c. Porphyrites of various kinds.

c. Basalts in great variety, including
Olivine-basalt,
Amygdaloidal-basalt,
Dolerite,
Diabase, and
Diorite.

r, Volcanic Ash, Tuff, and
Breccia.

METAMORPHIC ROCKS.

Mica-schist of various kinds, including
r. Garnetiferous Mica-schist,
Hornblende-schist and-gneiss.
c. Gneiss of various kinds.

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* See also C. Reid's "Holderness," p. 18.

† For full information respecting some of these rocks see Mr. Harker's descriptions in Appendix C.

c. Quartzites in great variety, and evidently of diverse origin.
r. Flaggy slate.
c. Vein Quartz of many colours.
r. Agate and Carnelian.
Jasper.

SEDIMENTARY ROCKS.

c.	Grits, conglomerates and Breccias of several kinds, probably of different ages, from the Silurian upwards.	
c.	Fossiliferous Limestones of various colours, *Spirifer*, *Productus*, *Lithostrotion*, etc.	*From the Carboniferous.*
r.	Chert.	
c.	Sandstones in great variety, red, yellow, and white, including Carbonaceous Sandstone, Galliard or Gannister, and Micaceous Sandstone.	
c.	Coal.	
	Pale hard Magnesian Limestone.	*Permian.*
	Mottled Sandstone	
c.	Dark fossiliferous Limestone,	*Lower Lias.*
	Septarian nodules, and	
c.	Fossils (isolated), including *Ammonites jamesoni*, *oxynotus*, *capricornis*, *raricostata*, *etc.*, *Belemnites acutus*, *etc.*, *Pinna folium*, *Cardinia Listeri*, *Gryphœa arcuata*, *etc.*, *etc.*	
	Fossiliferous shale and	*Middle Lias.*
	—— Ironstone, containing *Ammonites spinatus*, *Protocardium truncatum*, *etc.*, *etc.*	
	Shale.	*Upper Lias.*
	Jet.	
c.	Fossiliferous Nodules.	
c.	Fossils (isolated), including *Ammonites communis*, *bifrons*, *crassus*, *etc.* *Belemnites sp.*, *Leda ovum*,[*] *etc.*, *etc.*	

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[*] These lists of fossils might be indefinitely prolonged.

r.	Oolitic limestone.	*Oolites.*
r.	Calcareous grit.	
r.	Earthy limestone ("Scarbro'" or "grey limestone."	
c.	Septarian nodules...	*Kimeridge.*
r.	Black paper-shale. Fossils (isolated) including *Bel. jaculum, Am. Speetonensis, Vermicularia Sowerbyi.*	*Neocomian.*
r.	Red chalk with *Bel. minimus*	*Red Chalk.*
r.	Hard white chalk with grey flints, like the chalk of Flamborough.	*Upper Cretaceous.*
c.	Soft white and creamy chalk, and black, yellow, red and pinkish flints, unlike anything seen in any place in Yorkshire; containing fossils—*Belemnitella* sp.; *Ananchytes* sp.; *Holaster* sp. and other Echinoderms; *Inoceramus* sp.; etc., etc.	
c.	Black flints with green-stained exterior; limestones bored by Pholas, Saxicava and Cliona; fragments of Molluscs; and other traces of a sea-bottom.	*Sub-glacial ?*

APPENDIX C.

PETROLOGICAL NOTES ON SOME BOULDERS FROM THE BOULDER-CLAYS OF EAST YORKSHIRE. BY ALFRED HARKER, M.A., F.G.S.

[NOTE —The numbers in brackets refer to slides in the Woodwardian Museum Cabinet at Cambridge.]

[929] From the Lower Purple Clay, South of Withernsea. A conglomerate including small rounded pebbles, some of dark limestone, about one-fifth of an inch long, and grains of quartz in a compact ground.

Under the Microscope a slice shows abundant rounded grains of quartz, with rolled pebbles of (probably dolomitized) limestone, imbedded in a mass of carbonate of lime. This calcareous matrix often shows the characteristic cleavage of crystalline calcite; but in other places are little ellipsoidal concretions with both concentric and radial structures, and showing the black cross in polarized light. Though less coarse than the usual type, there can be no doubt that this rock is the "Brockram," which forms the basement of the Permians in the Eden Valley. A slide [514] from near Appleby shows precisely the same characters, including the little oolitic concretions. Brockram boulders were long ago recorded by Phillips from the Yorkshire coast, where they are not at all uncommon.

[930] From the Basement Clay at Bridlington Quay. A dark grey doleritic rock, showing little glistening felspars in a dark compact ground-mass.

Micro. The porphyritic felspars, about one-eighth of an inch long, are rather rounded, as if by corrosion, and sometimes enclose portions of the ground-mass. They are very clear, and show Carlsbad-twinning, but the finer twin-lamellation is very difficult to detect. This is owing to the nearly straight extinction of the crystals, which must belong to a variety of the oligoclase-andesine series. Augite occurs in rather smaller crystals with good forms and a greenish colour. These minerals, with a few rather rounded magnetite crystals and rare prisms of apatite and flakes of biotite, are imbedded in a fine ground of decomposed felspars with magnetite granules.

[931] From the Basement Clay at Bridlington Quay. A very fine-grained dark dolerite, showing under a lens minute needles of felspar.

Micro. The felspar is mostly in bundles of "lath-shaped" prisms, with albite-twinning and extinction-angles suggesting labradorite; but there is some later felspar with a rather interstitial arrangement and exhibiting zonary shading between crossed Nicols. The augite, in light-brown granules, moulds the dominant felspar, while the magnetite grains are slightly posterior to the augite.

[932] From the Basement Clay at Bridlington Quay. Another rock of compact appearance, showing only minute narrow prisms of felspar scattered through a black ground.

Micro. The specimen is found to be an olivine-dolerite. The mineral first consolidated is magnetite, which is abundant in rude octahedra. Then follows olivine in rather rounded irregular crystalline grains, partially converted into grass-green serpentine with separation of magnetite dust. The lath-shaped felspars show albite, and sometimes Carlsbad-twinning, and appear to be of a basic variety. A minor portion of the felspar is of less basic character; this is of rather later consolidation, and so in less perfect crystals, and it has a zonary structure. The occurrence of these two generations of felspar links the rock with the dolerites rather than the diabases. The augite, brown in section, is in plates moulding round the dominant felspar and other earlier minerals.

[933] From the Basement Clay near Flamborough North Landing. A basalt exhibiting green spots of olivine, black crystals of augite, and little shining needles of felspar in a dark ground.

Micro. The olivine is in rather large crystalline grains, for the most part fresh, but locally converted into grass-green serpentine. The augite is in well-formed crystals of a purplish-brown colour with marked pleochroism. In ordinary light it shows a zonary structure, the margin of each crystal being much more deeply coloured than the interior. The felspar is in elongated (lath-shaped) crystals with fine albite-twinning and the extinction-angles proper to labradorite. A few felspar crystals of later formation are less perfectly built: these have a blurred zonary shading when viewed between crossed Nicols, and are probably near andesine in composition. The ground-mass of this rock is isotropic, and seems to be composed more or less of glassy matter. Probably none of these doleritic and basaltic rocks are of sufficiently marked types for the precise localities to be identified. It can only be said that they do not resemble either the Whin Sill or any of the known dykes of Northumberland and Durham, but that they might probably all be matched in Southern and Western Scotland.

[934] From the Basement Clay at Bridlington Quay. The specimen shows a dull brown ground-mass enclosing partially destroyed felspars up to half-an-inch in length. They have irregular quadrilateral outlines, and the interior is largely occupied by a dark brown material.

Micro. The slice is seen to be deeply decomposed, but the large felspars still show a very fine cross-lamellation with narrow extinction-angles pointing to andesine. The slide contains plenty of a green chloritoid product, probably occupying the place of pyroxenic minerals now destroyed. Large patches of secondary calcite also occur, and the only original minerals surviving in a fresh condition are apatite, in abundant hexagonal prisms, and irregular ragged grains of magnetite. The ground-mass consists mainly of felted microlites of felspar, but probably there has been a glassy residuum also. Portions of this ground-mass have been caught up by the porphyritic felspars. The rock is an altered andesite ('porphyrite' of many authors), and presents a very close resemblance to those from the Cheviots.

[935] From the Basement Clay at Bridlington Quay. A handsome crystalline rock, shewing grey felspars and dark mica.

Micro. The slice consists mainly of large felspar crystals. Some seem to be ordinary orthoclase; others have the minute "cross-hatching" of microcline, and include intergrowths of finely-lamellated albite (?); others again are of striated acid plagioclase containing numerous little rectangular patches of orthoclase with parallel growth. A curious feature is seen at the contact of the several crystal plates, where they seem to interlock in an intricate fashion recalling a micropegmatite intergrowth. There is plenty of pyroxene, pale-brown in section, of earlier consolidation than the felspar but enclosing magnetite grains. In addition to the augite-cleavage, it possesses a diallagic structure, which is often developed in the interior of a crystal but not at the margin. Good hexagonal prisms of apatite are very plentiful. The brown mica (biotite) is less abundant than appears from the hand-specimen: it penetrates and is enclosed by the felspar.

[936] From the Basement Clay at Dimlington. A beautiful crystalline rock, resembling the last though darker in general appearance. The felspar shows on many of its crystals an iridescence like that of the well-known Labrador mineral. A black pyroxenic mineral and flakes of dark lustrous mica are also to be seen on the specimen.

Micro. The felspar appears to be mainly orthoclase or soda-orthoclase, each crystal plate presenting, as a rule, an optically uniform field, though there is some veining with a different felspar-substance. The microcline structure is not detected. The pyroxene, grass-green in section, is for the most part typical diallage. As before, the "schiller" structure sometimes affects only the interior of a crystal, but, on the other hand, there is sometimes schillerization on two intersecting sets of planes. A system of parallel lamellar inclusions is often developed, though in a much slighter degree, in the felspar, and may account for the play of colour noticed in the hand-specimen. The diallage is earlier than the felspar, but includes apatite in large and small prisms and magnetite in octahedra and more complex shapes. Brown dichroic biotite is associated with the diallage, and also some hæmatite. A few little crystals with very high refractive index and apparent tetragonal habit may be zircon.

These two specimens represent a very peculiar petrological type, which I am not able to parallel except by the augite-syenites, so largely developed in southern Norway, as described by Brögger and others. Indeed, there can be practically no doubt that these boulders had their origin in that country.

[937] From the Basement Clay at Bridlington Quay. A gneiss exhibiting light felspathic streaks or bands, half an inch or more in width, alternating with dark micaceous layers. There is also plenty of white mica in glistening flakes set parallel to the gneissic banding.

Micro. The chief constituents are felspar, often in broken crystals, lenticular streaks composed of aggregates of clear quartz-grains, and bands of closely-packed mica-flakes, both muscovite and biotite. The felspar seems to be partly orthoclase, but is mainly an acid plagioclase with fine striation and often cross-lamellation. The crystals are often bent, and the twinning seems to be related to the strain. Quartz grains are sometimes enclosed in the felspar. The other minerals present are magnetite, in rudely-built crystals, and reddish isotropic garnet, often broken and slightly drawn out in the direction of foliation.

[938] From the Lower Purple Clay, South of Withernsea. A compact white rock, enclosing black hornblende crystals, up to one-

fifth of an inch in length and with partial parallel arrangement, and rounded grey spots of quartz. It may be styled hornblende-gneiss.

Micro. The hornblende sections are greenish-brown or dull-green, with strong pleochroism, vibrations parallel to the axis of greatest absorption (which is inclined only 4° or 5° to the long axis of the crystal) giving a deep green tint. The crystals are of irregular outline, and enclose quartz grains at the margin. The bulk of the slice consists of quartz and altered felspar. The latter presents a finely-granulated appearance, recalling the so-called "saussurite," and chlorite and scaly white mica are closely associated with it. The larger quartz-grains have, between crossed Nicols, the shadowy aspect due to internal strain, and they pass at the margin into irregular areas of granular quartz-mosaic. All these appearances indicate the action of great mechanical stresses, and the rock must have formed part of an area of metamorphosed crystalline rocks, such as that of the Scottish Highlands or Norway.

[939] From the Basement Clay near Flamborough North Landing. A mottled dull greyish-green and white rock, in which quartz, felspar, etc., may be detected by the eye.

Micro. This specimen again gives unmistakable evidence of great stresses having operated in the *massif* from which it was derived. It must have been originally a biotite-granite, and has been much altered, though without receiving a gneissic or schistose character. The quartz which builds much of the slice is in patches of granular mosaic, traversed by innumerable rows of fluid-pores, which have a parallel disposition, and traverse all the granules uninterruptedly. This is no doubt an effect of the stress. The outlines of the felspar crystals are partly preserved, but their substance is entirely replaced by secondary products, including chlorite and quartz. The dark mica has also perished almost completely.

Gneissic and similar rocks do not occur *in situ* in the North of England. Doubtless the last three specimens might be matched in the Highlands of Scotland, but it is impossible to assert that that is the home of these particular boulders, and Norway seems more probable.

[940] From the Basement Clay at Bridlington Quay. A finely-granular, pink, felspathic rock.

Micro. This is what some geologists would term a "binary granite," though it has not the normal granitic structure. It consists almost solely of quartz and felspar the quartz being of earlier consolidation, in irregular rounded grains, moulded and enclosed by the felspar. The latter is opaque and much altered, but appears to have been partly orthoclase, partly striated plagioclase. A few grains of magnetite occur.

[941] From the Basement Clay at Bridlington Quay. A normal granite of medium grain.

Micro. Both light and dark micas are abundantly present, sometimes with parallel intergrowth of the two. Felspar crystals often contain flakes of muscovite set parallel to the two principal cleavages, suggesting a secondary origin for this portion of the mica. The felspars are both orthoclase and an acid plagioclase. The latter has fine striation, the lamellæ often bent and discontinuous, and frequently cross-twinning (the pericline law) in addition. The orthoclase is often veined with albite (?) ('microperthite'). Clear quartz in grains of varying extent is the latest-formed constituent.

No granite in the North of England has these characters, though rocks of this type occur in various parts of Scotland.

[942] From the Lower Purple Clay, South of Withernsea. A red granite, showing abundant pink felspar, colourless quartz, and dark mica (biotite).

Micro. The deep brown biotite is often arranged interstitially to the felspar, an uncommon feature in such rocks. The felspar is partly orthoclase, partly striated oligoclase, but mostly microcline in broad crystal plates, showing in polarized light the most beautiful 'cross-hatched' structure, and often having the other felspar in shreds intergrown with it. The quartz, which has rows of crowded minute fluid-pores, is mostly later than the felspars, but occasionally included by them.

[943] From the Lower Purple Clay, South of Withernsea. A biotite-granite, closely resembling the preceding, and having good thick flakes of dark mica.

Micro. This slide shows the same abundance of microcline, besides 'microperthite'—orthoclase veined with albite in crystallographic relation. The quartz is often in rather mosaic-like aggregates, possibly connected with a certain amount of crushing in the rock-mass, and a little white mica, evidently secondary, may also be a result of mechanical disturbance. These two specimens are not unlike some of the Scotch granites, such as those of Mull and Criffel, but no specimens I have seen from Scotland present exactly the same characters as the boulders. The granite of Eskdale, in Cumberland, offers the closest resemblance to our slides, but this rock, though well-known in the Lancashire drift, is not one that we should expect to find in East Yorkshire.

ON FURTHER EXPLORATION OF A CAVE AT ELBOLTON, NEAR THORPE, IN CRAVEN. BY REV. E. JONES.

During the summer of 1888 some members of the Craven Naturalist Society had been exploring a small cave near the summit of Elbolton, particulars of which were given in a paper printed in the Proceedings of this Society last year. We made an experimental trench across the first chamber, and dug down to the depth of near ten feet. At this point the material taken out of the trench so encumbered the work that the trench was discontinued. A quantity of bones, both animal and human, were discovered, together with bone-pins and pieces of early British Pottery.

This year a Committee was formed to raise funds and to explore the cave systematically. The latter could only be done by clearing the whole deposit of the first chamber, and hauling it to the surface. Needful consents were courteously given by the landlord, Mr. N. H. Kelsall, and by the Lord of the Manor, Sir Chas. Tempest; and apparatus for winding the material was kindly lent by Mr. J. Ray Eddy. Two careful miners were engaged, and the work commenced on August 19th, and is still in progress, one or more of the committee superintending the work. We have also had the advice and assistance of Mr. James W. Davis and other experienced workers. The original surface level of the floor was marked on the walls, and divisions marked off three feet apart on the North and South walls, and numbered in feet from a datum line at the cave mouth. These markings correspond with a plan of the cave in which the whole surface is divided into square feet. As the excavation proceeds the floor alters in shape, and so other plans, at various depths, say five, eight, and twelve feet will be made. In this way any special object, or any alteration in the material worked, can have its exact position noted.

When all the loose material that had been worked in the trial operations of last year was hauled out of the cave, the regular and more orderly excavation commenced. The greater part of the material worked has been made up of loose angular fragments of limestone rock fallen from the roof, keeping constant in character throughout, without evidence of stream action, of rolled stones, or gravel. This is interspersed with abundance of bones and fragments of pottery. All the human remains have been found in this deposit. It is of varying thickness, from four feet at the east end, where it rests on stalagmitic breccia, to more than 15 feet at the west end of the chamber. At the west we have not yet pierced through this stratum. Human remains, with pieces of pottery and some charcoal, have been found at this end, at a depth of 12½ feet from the original level; though in the other end the human remains were only covered to the depth of three to five feet. At the west end the bones are scattered as if the ground had been disturbed by either former explorers or the bones scattered by dogs or wolves, while we have numerous evidences of gnawing of animal bones. I have not noticed such markings on human bones.

At twelve feet south from the datum, a skeleton nearly complete, was found; in a recess three feet further another was seen; and in the middle of the floor a third was obtained. These had not been disturbed, and were seen in the position of burial. The one in the recess and the one in the middle of the chamber had been buried in an upright sitting posture, the knees being close to the skull, the thigh bones still inserted in the sockets of the pelvis. The skeleton of the first was similarly bent so as to occupy little space, but the body had evidently been laid sloping and not erect. The skull of the one that was buried in the middle of the floor was crushed by the overlying *débris*, while the other two being better protected by the sloping sides of the cave are fairly preserved. They are all evidently Neolithic of the long-head type. Special care was taken to examine the ground in the vicinity of the interments. There were no flints nor any instruments buried with them. The two skeletons that were buried near to the south wall were protected from falling rock by the side walls, while semi-circular fenders of large stones. neatly built, were placed between the bodies and the rest of the cave. The quantity of bones of other animals brought out of this angular stone deposit is very great. These bones have been washed and now await the assistance of those who can determine their character. The bones of horse, boar, bos-longifrons, red deer, sheep, dog or wolf, fox, badger, smaller carnivora and rodents are very abundant, and it is quite possible that with better knowledge of the remains other species could be added. All the larger bones other than human have been broken, many split lengthwise, most likely done by the cave-men to obtain the marrow.

Charcoal with calcined bones has been found in three or four places, and at 18 ft. north, depth 9 ft. 6 in., evidences of an actual hearth is seen. Here also we found that in addition to wood fires they used peat.

The fragments of pottery are of an interesting character. They are all Neolithic and crude, seemingly made from the clay found in the cave, and formed into circular vessels. All the pieces are coated with charcoal on the inside, and in some cases the pot has been blackened to the depth of a quarter of an inch. The ornamentation is varied in a few pieces, approaching the condition, but not, I think, identical with pottery of the Bronze Period. In some cases we have straight lines cutting one another diagonally, making diamond patterns. In others the diagonals do not cross one another, but make a pretty design like the "herring bone pattern." Others are imprints of bone or of finger nails. Altogether we have five or six designs in the bits of pottery from this cave.

The present entrance to the cave seems to have been a pot-hole about 20 feet in depth to the level before the excavation begun. While it was occupied and used by the cave-men footholds well polished by use show the means whereby they clambered in or out of the cave.

At one time this pot-hole would be filled with clay, which after a time slipped through down to the cave floor. This mass of clay was seen to be two feet thick under the cave mouth, and spreading mainly towards the east, resting on the angular stuff of loose stones. In this clay were found the jaws of the Ursus ferox and some smaller carnivora. Similar clay deposits have been found beneath and amongst the stalagmitic floor, underneath the angular *débris*, at 18 feet south. This stratum remains yet to be worked out, but from it we have already obtained numerous large bones, femurs, pelvis, &c., of bears, and giving promise of further finds when this stalagmite and the large fallen blocks of stone have been removed. As yet we have not sufficient data to determine the age of this clay deposit.

In the cave we have found a few bone-pins with annular rings, similar to those found in Belgian caves, also two or three worked bones the use of which is unknown.

Amidst the *débris* we have come across a few carried stones, grits for pot-boilers, two river-rolled limestone pebbles, and a smooth Silurian slate that may have been brought to sharpen their bone instruments. A few antlers of large red deer have been found in the same material, but none of them seem to have been used by the cave-men as tools.

The work of excavation is still proceeding. The Cave Committee are grateful for the advice and assistance of more experienced explorers, and hope to continue until this small cave has been completely investigated. So far we think that the deposit of clay, containing bones of bear, &c., which underlies the loose stratum of angular stones was deposited prior to the occupation of the cave by man; that Neolithic man made use of the cave first as a dwelling and sheltering place, and afterwards as a place of burial.

YORKSHIRE PETROLOGY. PART II. THE LAMPROPHYRES.

BY THOMAS TATE, F.G.S.

A series of eruptive rocks, somewhat alike in composition and age, extends along the border of West Yorkshire from Ingleton by way of Dentdale, Garsdale, Sedbergh, around the flanks of Howgill Fells, and thence to Middleton-in-Teesdale. The members of this series exposed in the neighbourhood of Ingleton have already been described in a former paper (vol. ix., page 380). In the present communication it is proposed to deal with the allied rocks, as they may be studied in the Dentdale area some ten miles further north.

Leaving Ingleton by the old river course and skirting Whernside we may descend by Deepdale into the lovely valley watered by the River Dee. Below Dent we find seven or eight exposures of these traps in two localities; three in a stream to the west of Millbeck on the south side of the dale, and five in Helmsgill running up the northern slope. A walk of about a mile down the valley from Dent brings us to Helmswood, and ascending the beck till past the waterfall we enter upon the open pastures lying at the foot of Helmsknott, and it is here, within a distance of one hundred and thirty yards from the fall, that we meet with a series of five dykes exposed in or near to the bed of the stream in regular sequence as we ascend. The chronology of the beds in contact with the intrusions in the Ingleton area is somewhat obscured by the faulted character of that district, but the series of mica-traps outcropping in Helmsgill presents no such difficulty, the succession being quite clear. The beds intrusively penetrated belong to the Coniston Limestone and its underlying calcareous shales (Ordovician), all dipping uniformly at a moderate angle to the south-west. The uppermost (geologically) of these intrusions occurs near the waterfall, on the west bank of the stream. It weathers to a warm brown tint, is somewhat angular in outline, and partially moss-hidden, not more than three or four square feet being exposed. Of all the series this is the toughest and best preserved rock. A fresh hand-specimen is purple-hued, due to an intimate mixture of pink grains with brown metallic flakes, having a somewhat uniform texture. Throughout this ground-mass larger flesh-coloured crystals, up to one-fifth of an inch across, are sparsely scattered, and, more rarely, clusters of hexagonal mica-plates each fully a quarter of an inch in breadth. To this macroscopical description we must add, that a polished face when viewed by reflected light, reveals numerous pale-grey bodies, presenting in some cases the outlines of hornblende sections; and the mica-plates of the ground-mass are seen to have a fairly uniform arrangement parallel with the face of the dyke, the rock slices often splitting along such mica-courses in a provoking manner. The pink matter found in the spaces between the mica-plates is all that remains of the original felspathic constituent of the rock (fig. 24).

Microscopically, the most prominent of the three chief mineral components, and the only one presenting idiomorphic contours is the brown mica. In each dyke of the Helmsgill group we find micas representing two different periods of consolidation in the life-history of the rock. Here the older are larger, mostly hexagonal-plates of a deep-brown tint, much corroded along their edges, and penetrated by the ground-mass (figs. 25-26). Sections transverse to the cleavage are of a pale-honey tint, contrasting sharply with the olive-green of the Ingleton micas, as well as in the absence of the darker lines formed by the ferric oxides concentrated between the cleavage planes and the consequent bleaching of the mineral. Like the hexagonal plates of the same age, their boundaries are exceedingly ragged and labyrinthine (fig. 27); often these sections have suffered mechanical deformation, the broken and displaced fragments lying contiguously (figs. 28, 29, 30). The younger, fresher-looking micas occur in rectilinear plates of a pale-brown tint, with lighter margins and frayed ends (figs. 31-32), but this clear periphery is characteristic of the older micas in this rock rather than of the younger, the aggregated iron forming a black rim to the plate (fig. 26). They are strongly dichroic, and polarize with vivid chromatic effects, in this respect differing from the magnesian micas present in Phillips's dyke, the rock this most nearly resembles. The resemblance is rather in the felspathic constituent, for in both rocks we have two generations of felspars ; the small crystals of uniform size diffused through, and originally forming the chief component of the ground-mass ; and larger crystals, solitary, or grouped in clusters, porphyritically embedded in the ground-mass to some extent, in fact, repeating the "glomero-porphyritic" structure of Prof. Judd. Each of these glomero-porphyritic clusters is enclosed in a framework of secondary magnesian mica generated around it. The external crystalline faces of the felspars from all the cluster members of this group of dykes are well-nigh obliterated, not being at all so definite as those of the clusters in Phillips's dyke ; but the internal boundaries have been from the first, in both cases, irregular and ill-defined. The result is that while the clusters in this dyke have succumbed to degrading influences even to the limit of effacement, the similar clusters in Phillips's dyke having resisted corrosive agencies most effectually, present to us the freshest felspars yet met with in these Lamprophyres. Of the characteristic twin-lamellation of plagioclase felspars there is no trace ; and the little that remains in evidence, whether of form or colour, favours orthoclase, as analogy would suggest. The orange-red particles of the original felspar are by no means so abundant as we found them to be in Phillips's dyke. They are accompanied here and there by a cumulous aggregate of minute granules of opaque white matter, probably kaolinite, and in some examples the nature of the felspar is completely masked by kaolinisation. If we select one of the least altered, it may show kaolin traversing cleavage planes (fig. 33), a process, which when more advanced, and in the glomero-porphyritic clusters, produces effects obscurely simulative of olivine pseudomorphs, a suggestion however negatived, by reflected illumination revealing surviving patches of pink felspar (figs. 34, 35. 36). These figures may be compared with those of similar effects noticed in the white dyke of Dale beck (figs. 16-17), and which may have been fashioned in like manner, no primal component having survived to marshal us the way we ought to go.

The nature of the original ferro-magnesian ingredient of this dyke is no longer determinable. The micro-granular greenish-grey material diffused throughout the slides has in one instance retained the crystalline faces of hornblende, and may be seen in the upper corner of figure 24. But the field is sprinkled over with the iron-ore from this source, in the form of opaque grains and crystals of magnetite and titanoferrite.

At one point what seems to have been originally a pocket of hornblende has been converted into brown mica and sphene. The latter mineral occurs in well-formed crystals and plates of a golden-brown tint, by transmitted, reddish by reflected light. Usually two, if not more, of the crystalline faces are sharply defined by dark borders, and their surfaces are very much pitted (figs. 37-38). The mineral is pleochroic, polarising in moderate tints. An opaque patch of titanoferrite, not yet transformed into sphene, but with the alteration product, dark by transmitted, white by reflected light (leucoxene) coating its interior, lies in one corner of figure 37. The mica plates in this inclusion are very pale-brown, and have a peculiar labyrinthic structure (fig. 38). In another case, a cavity apparently vacated by a hornblende crystal, is filled in with lath-shaped plates of an indeterminate mineral, brown by transmitted, salmon-tinted by reflected light, radiating from its internal surface: the clear interspaces to polarise feebly (fig. 39). Strongly polarising calcite plates and powder, or a feebly dichroic and polarising pale-green substance of the chloritoid family, fills in many of the cavities vacated by felspar or hornblende crystals. To these must be added a few blebs of pyrites, and, more sparsely, secondary quartz to complete our micro-petrographical description.

Sharply contrasting with the above dyke is the lowermost one of the group, which stands out boulder-like from the surrounding grass some hundred and twenty yards or so higher up the stream. The rock, of which not more than two or three cubic feet are exposed, weathers to a warm brown tint, a freshly fractured face having a steel-grey hue, glistening with densely-massed small hexagonal plates of brown mica, this being the only recognizable mineral in a hand-specimen, save here and there a porphyritic crystal of pink felspar.

By transmitted light the rock exhibits a hypo-crystalline structure, devitrification of the glassy magma, having developed doubly refractive prismatic felspar microlites, whose fan-like groupings, with little bunches and wisps within the interspaces, form one of its most striking features (fig. 40). Clear interstitial spaces under higher magnification may be resolved into a little residual isotropic glass, in which lie intimately interwoven feathery and felted bundles of acicular microlites, the *microlithenfilz* of the Germans (fig. 4). The somewhat longer microlites marshalled in radial symmetry usually based upon a porphyritic mica-plate (fig. 42), are anisotropic and of a salmon-coloured tint. Imbedded in this micro-crystalline basis lies a profusion of mica-plates in which the recurrence of phase is most markedly indicated by the deeply eroded dark-brown fragments of the older generation, contrasted side by side with the comparatively fresh and pale aspect of the younger series. In place of recognizable hornblende, we find in this, as in the uppermost dyke, pale-green patches of a dimly dichroic and faintly polarising chloritoid mineral, in many instances bordered by dwarfed mica-plates. There is also a considerable sprinkling of chocolate-coloured titaniferous magnetite in grains and skeleton crystals (fig. 14), portions of which have been transformed into small nearly colourless crystals of sphene polarising in firm tints. Pyrite with a brassy glint by reflected light ; calcite grains and quartz blebs lie scattered through the interstitial matter.

This rock with its plentiful supply of brown mica may at sight be distinguished from all the Lamprophyres yet examined. One of two boulders pointed out to the writer some three years ago at Ingleton, was at once assigned to this parent rock, an identification which subsequent microscopic comparison has confirmed.

None of the remaining Dentdale mica-traps call for special examination. Two of the exposures on the opposing slope are allied to the typical examples selected from Helmsgill for description. The other rocks belonging to this group are too much decomposed for profitable study or identification.

Specimens of these rocks, as they are collected, are being analysed in the Chemical Laboratory of the Yorkshire College, under the personal supervision of Mr. Bothamley, F.I.C., and the results of this work we hope to publish in a subsequent paper.

Explanation of Plates.

Plate xiv.

Fig.		
24.	Mica-syenite. Above the waterfall Helmsgill ...	× 2.
25.	Brown mica : hexagonal plates, corroded ...	× 50.
26.	Do. do. with pale periphery...	× 30.
27.	Do. rectilinear plate, with rugged boundary	× 20.
28.	Do. do. broken and displaced	× 20.
29.	Do. do. do. ...	× 20.
30.	Do. do. do. ...	× 15.
31.	Do. do. younger generation ...	× 50.
32.	Do. do. do. ..	× 50.
33.	Felspar with kaolin following cleavage ...	× 15.
34.	Felspar pseudomorphs mimicking olivine ...	× 50.
35.	Do. do.	
36.	Do. do.	
37.	Porphyritic inclusion of mica and sphene.. ...	× 10.
	Do. Titaneferrite and leucoxine at × ×	
38.	Mica-plate, at × in Fig. 37 : Labyrinthic structure	× 50.
39.	Hornblende pseudomorph : mineral not identified ...	× 10.

Plate xv.

Fig.		
40.	Mica-trap. Lowest dyke Helmsgill	× 50.
41.	Do. "Microlithenfilz"	×200.
42.	Do. Microlites based on mica-plate ...	×200.

THE STRUCTURE AND AFFINITIES OF LEPIDODENDON.

BY THOMAS HICK, B.A., B.SC., DEMONSTRATOR AND ASSISTANT LECTURER
IN BOTANY, THE OWEN'S COLLEGE, MANCHESTER ;
AND WILLIAM CASH, F.G.S., F.L.S., F.R.M.S.

The researches of Witham, Binney, Carruthers, and above all, the classical investigations of Williamson, into the histology and anatomy of Lepidodendron have made us so familiar with the chief structural features of the plants belonging to that genus, that it can scarcely be regarded as premature if an attempt be now made to

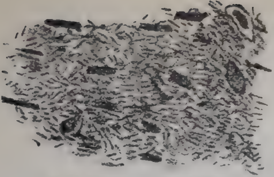

FIG. 24. x 2.

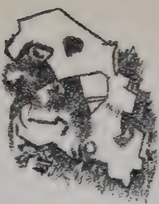

FIG. 25. x 50.

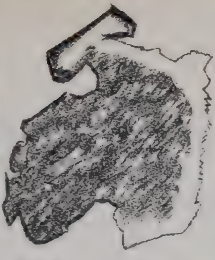

FIG. 26. x 30.

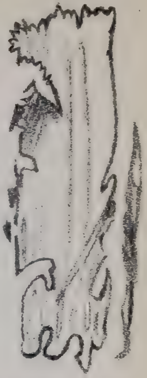

FIG. 27. x 20.

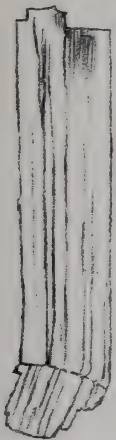

FIG. 28. x 20.

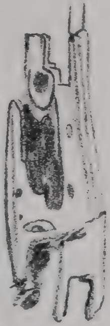

FIG. 29. x 15.

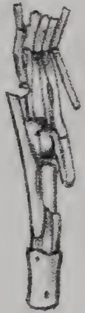

FIG. 30. x 15.

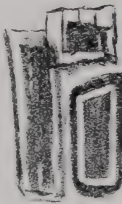

FIG. 31. x 50.

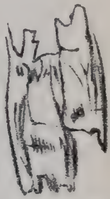

FIG. 32. x 50.

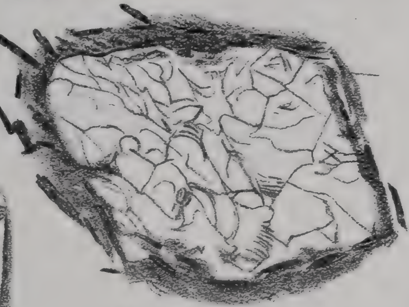

FIG. 34. x 25.

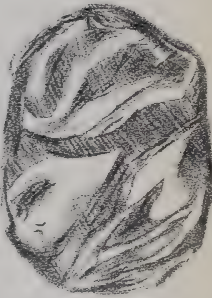

FIG. 35. x 25.

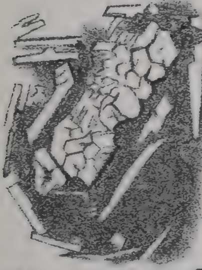

FIG. 33. x 25.

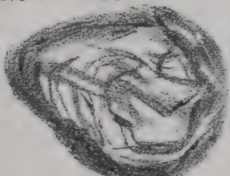

FIG. 36. x 25.

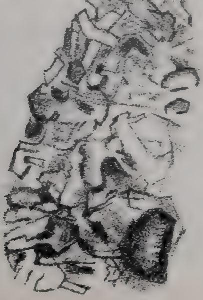

FIG. 37. x 10.

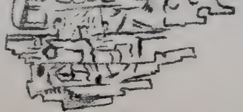

FIG. 38. x 150.

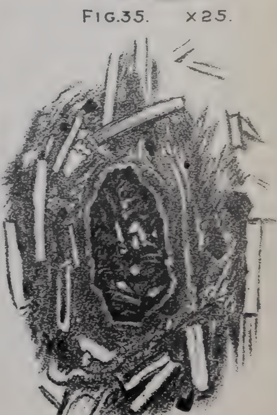

FIG. 39. x 10.

TATE: LAMPROPHYRES.

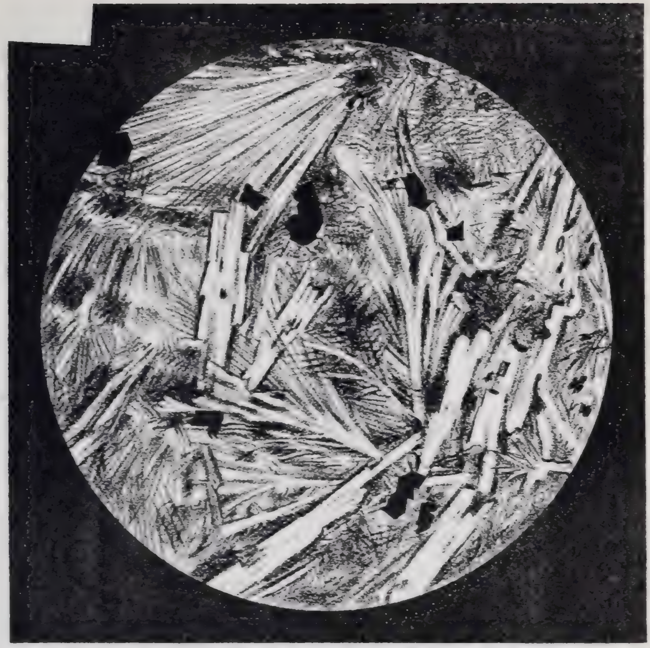

FIG. 40. x 50.

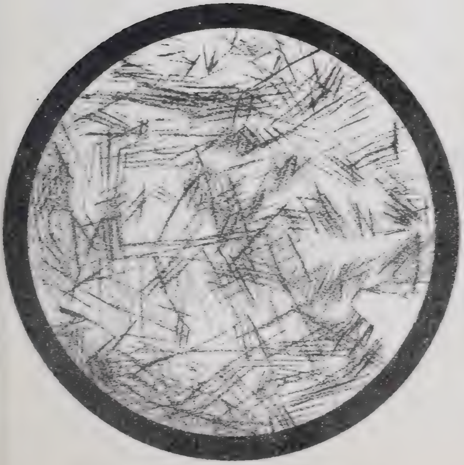

FIG. 41. X 200.

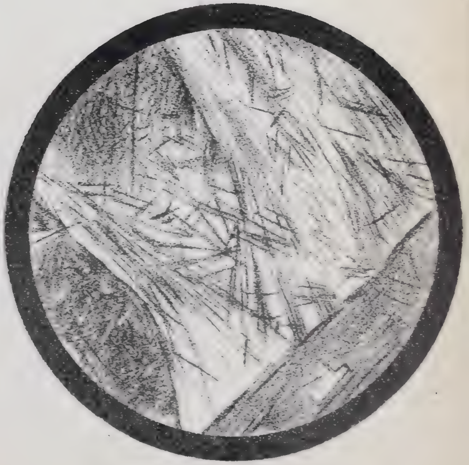

FIG. 42. X 200.

TATE: LAMPROPHYRES.

assess their morphological and taxonomic significance. In venturing to undertake the task of doing so, we have endeavoured throughout to present as facts only such as seem to be well established, and to maintain a sharp distinction between the facts and the conclusions we suggest as deducible therefrom. It need scarcely be said that the researches of Williamson have furnished us with nearly all the materials required for the descriptive part of this paper, but care has been taken to verify the statements made, by an appeal to actual specimens and preparations, wherever these were to be obtained. For this part of the work we have been greatly indebted to Messrs. Spencer, Binns, and Lomax, who have kindly allowed us to examine their specimens of Lepidodendron and compare them with those in our own cabinets. In addition to this we have profited very largely by the kindness of Prof. Williamson himself, whose readiness to impart information on all occasions and in any way, deserves hearty and sincere recognition. In saying this, however, we must add, that in no way is he to be held responsible for anything herein contained which goes beyond the facts and conclusions put forward in his own publications.

With respect to *Lycopodium* and *Selaginella*, no botanist is unfamiliar with the details of their organization and structure, but we have deemed it advisable to summarise the fundamental and characteristic features of the stems, in order to give point to the comparison made with that of *Lepidodendron.*

It has not been thought necessary to deal with the roots, leaves, and fruits of *Lepidodendron* with the same fulness as in the case of the stem, nor from our limited knowledge would it have been possible to do so. At first sight, it might seem that this would vitiate to some extent the conclusions we have attempted to draw as to its systematic relations with *Lycopodium* and *Selaginella.* Further reflection will show however that such is hardly likely to be the case. As regards roots, it is well known that in existing plants there is great uniformity in structure, even in groups that are widely separated and that root characters are seldom used as taxonomic distinctions. From the systematist's point of view leaves are more valuable, especially in the distinction of genera and species. But in the distinction of higher groups their value is variable, and is notoriously small in the case of the group to which the genera we are dealing with belong.[*] In *Lepidodendron* the want of further knowledge of leaf structure is undoubtedly felt, but what we do know points to the same conclusions as the structure of the stem, or at least is not opposed to them. The fruits are of prime importance in the search for affinities, but rather on the ground of their general organization and the nature of the reproductive bodies they bear than on the minuter details of their structure. This is well seen in the living genus *Lycopodium*, in which there are species *with*, and at least one *without*, a distinctly differentiated fruit cone.

On these grounds we are of opinion that our limited knowledge of the fruits, leaves, and roots of *Lepidodendron*, though much to be regretted, and to be remedied at the earliest possible moment, while suggesting caution, ought not to deter us from attempting to evaluate the facts we have already acquired.

LEPIDODENDRON.

In summarising the anatomical and histological characters of the genus *Lepidodendron* we will take the organs in the order usually followed by descriptive writers. There is some objection to this, inasmuch as it is impossible to keep to one type of the genus in all cases, while in others the type to which the organ belongs cannot be definitely determined. But the advantages of this course appear to be much greater than those of any other, and we have therefore adopted it.

I. THE ROOT.

Most palæobotanists are agreed that the roots of several Carboniferous genera must be sought in *Stigmaria*, seeing that stems of *Sigillaria*, *Lepidodendron* and *Knorria* have all been found in organic connection therewith. But there is some divergence of opinion as to whether *Stigmaria* itself or its appendages are the true roots. Williamson[†] holds that the axis of *Stigmaria* "viewed as an organ" is a root, and that the appendages are rootlets. Briefly stated, the following is the structure of the axis and appendages of *Stigmaria*, so far as it is known.

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[*] **Sach's Text Book of Botany, 2nd Eng. ed., p. 461.**

[†] "*Stigmaria ficoides.*" **Palæontographical Society's publication, 1886.**

1. *The Axis.* Most specimens of Stigmarian axes, with structure, have lost both cortex and appendages, and exhibit only a cylindrical mass of wood or xylem, enclosing a cavity filled with mineral matter. Transverse sections show this xylem which had an exogenous mode of development, to be made up of wedge-shaped masses of scalariform tracheides separated by primary and secondary medullary rays. The tracheides have wide lacuna, are nearly square in cross-section, and, except at the apex of the wedges, form regular radial rows. A primary vascular bundle at the apex of the wedges cannot be distinguished. The nature of the tissue originally enclosed within the xylem cylinder is somewhat doubtful, but Williamson believes it was wholly parenchymatous. According to Solms-Laubach a layer of bast or phloëm surrounded the xylem, but this, as well as the inner parenchyma of the cortex, is very rarely preserved. The outer portion of the cortex which carries the apppendages is usually well-preserved, and consists of two layers:—

i. An outer composed of thick-walled parenchyma which is probably the primary cortex, and

ii. An inner composed of parenchymatous cells, elongated longitudinally, with pointed ends, and arranged in radial rows. These are probably the product of a secondary meristem zone or cambium layer lying at the outer periphery.

2. *The Appendages.* As in the case of the axis, the preservation of all the tissues of the appendages is extremely rare. The only perfect specimens hitherto published, so far as we are aware, are those figured and described by Williamson.* From these it would seem that the appendages have an unmistakable root-like appearance, both externally and internally, and occasionally branch dichotomously. In the young condition there is a single vascular bundle, enclosed by a thick parenchymatous cortex. The bundle has a triangular or ovate form in cross section, the apex being occupied by the initial group of tracheides. From the accounts given by Williamson, Solms-Laubach, and Schenk it would seem that the bundle is sometimes

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* **Memoirs: part xi.; Stigmaria ficoides: Palæontographical Society's publications, 1886.**

radial and at others collateral, and that the collateral bundles are capable of secondary growth. In all cases the xylem consists of a few scalariform tracheides, with parenchymatous rays between them when they are collateral.

II. The Stem.

The best figure and description of the internal structure of the stem of a Lepidodendron are given by Williamson in the eleventh part of his memoirs. Taken from a specimen supplied to him by one of us, in which the whole structure from centre to circumference is preserved, it affords a tolerably complete view of the structure and arrangement of the tissues met with in one of the best known types of Lepidodendron, viz., that described as *Lepidodendron selaginoides*, Carr. and Williamson, *L. vasculare*, Binney. It will be convenient therefore to summarise Williamson's account of this stem, and make it the starting point for the comparisons that are to follow.

1. The centre of the stem is occupied by a string of tracheides and vessels, circular in transverse section, among which are a few parenchymatous elements. The tracheides are either isodiametric or elongated longitudinally, but in both cases are scalariform or reticulated. The vessels are restricted to the periphery of the string, and appear to be mostly spiral (pl. xvi . *a*)

This string is spoken of by Williamson as the 'Vascular Medulla,' the 'Vascular Axis,' the 'Vascular Cylinder,' etc. It is obviously the xylem of either a single vascular bundle or of several vascular bundles.

2. Surrounding this string of tracheides and vessels is a zone of tissue termed by Williamson the *innermost cortex*. Though narrow he finds it divisible into three layers : (i.) an internal one of 'very minute cells (*b*) ;' (ii.) a middle layer 'in which the cells are of larger size (*b'*) ;' and (iii.) an outer layer 'in which the cells exhibit a tendency towards a cyclical arrangement (*b''*).' This 'innermost cortex' is the bast or phloëm belonging to the xylem of the 'vascular axis.'

3. At the outer periphery of the 'innermost parenchyma,' we come upon the *middle cortex* as Williamson terms it, (*d*) which consists of 'very delicate parenchyma, the cells of which at the inner margin exhibit a disposition towards a radial arrangement.

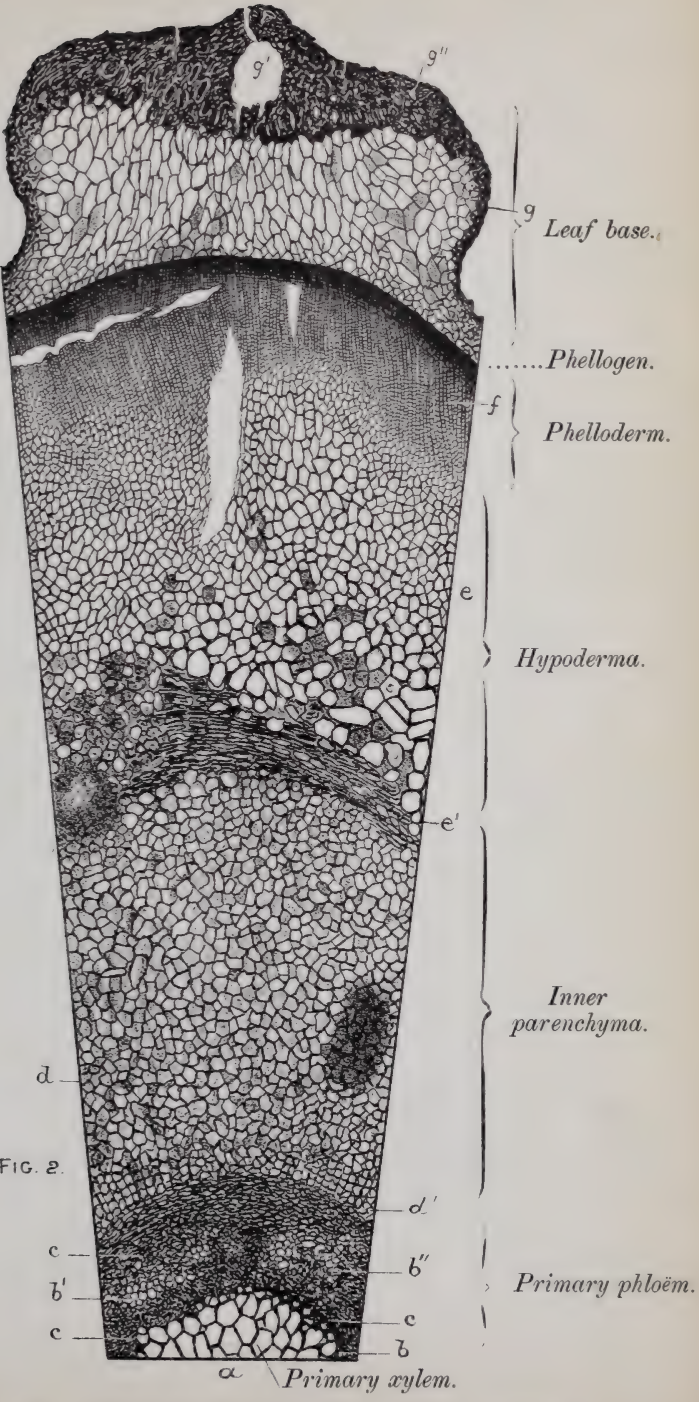

FIG. 2.

HICK AND CASH: LEPIDODENDRON SELAGINOIDES. After Williamson.

4. Lastly, the whole of the preceding tissues are enclosed by the *external cortex* (*e*). This "consists of strongly defined thick-walled cells which diminish from within outwards." "The smaller peripheral cells gradually pass over into crescentic clusters of radially disposed prosenchymatous cells (*f*)." This prosenchymatous tissue, according to Williamson, arises first in that part of the outer cortex which underlies the leaves and subsequently becomes a thick continuous zone, growing in breadth as the stem increases in age, by means of a cambium layer situated at its outer periphery.

From this description of the *external cortex* it is evident that we have here two distinct tissues, which it will be advantageous to keep separate. The strongly defined thick-walled cells of the inner zone (*e*) represents a part of the *primary cortex*, and to it, in strictness, the term *external cortex* should be confined. The prosenchymatous cells (*d*) are absent from the primary cortex of young twigs. They form indeed a *secondary tissue*, arising from a *secondary meristem*, and may be considered as a kind of phelloderm superadded to the primary tissues.

5. At the edge of the transverse section the external cortex runs out into the bases of the leaves (*g*).

6. In addition to the tissues already enumerated and described, and which may be regarded as fundamental and characteristic, the stem of *Lepidodendron selaginoides* when fully developed has a mass of secondary vascular tissue. This is the tissue that Williamson speaks of indifferently as 'the exogenous zone,' 'the vascular zone,' or 'the ligneous zone.' When present this zone of tissue is intercalated between the 'vascular axis' and the 'innermost cortex.' It consists of thin wedge-shaped masses of elongated scalariform tracheides, separated by medullary rays, and though often unilateral at first, forms at length a complete zone round the 'vascular axis.' The elements of these wedges increase in size from within outwards until a certain maximum is attained, after which no further increase occurs. By the action of a cambium ring the zone grows exogenously—i.e., by additions to the vascular wedges and the medullary rays at the outer periphery—and in this way an increase in the diameter of the stem is brought about.

7. Finally it should be mentioned that the vascular bundles that go to the leaves arise at the periphery of the 'vascular axis,' and therefore must pass through all the tissues external to that axis in their course outwards.

Such then is a description, as given by Williamson, of the structure of the stem of *Lepidodendron selaginoides.*

For purposes of comparison, it will be convenient to reduce this description to its lowest terms, and to express the essential facts in such a way as will enable us to detect points of resemblance or difference when we pass from *Lepidodendron selaginoides* to other types, and from these again to other genera.

Beginning at the centre of the stem, it is obvious that the "vascular axis' and the 'innermost cortex represent respectively the xylem and phloëm of an *Axile Vascular String or Cylinder*, which is made up of *the primary vascular bundles.* Whether this axile string is a single concentric bundle or an aggregate of bundles, and whether it is wholly made up of leaf-trace bundles or is partly cauline, is not definitely known. The more probable view is that it is an aggregate of bundles.

The 'external cortex'* and the 'middle cortex' of the above description offer no difficulty. They are obviously the equivalents of those divisions of the cortex which De Bary† terms *hypoderma* and *inner parenchyma.*

Hence the primary and fundamental structure of the stem of *Lepidodendron selaginoides* may be said to exhibit the following structures :—

(a) A central Axile Vascular Cylinder, representing one or more vascular bundles, and consisting of

i. A central string of xylem, enclosed by
ii. A zone of phloëm.

(b) An outer mass of tissue, forming the cortex, and divisible into

i. The inner parenchyma, and
ii. The hypoderma.

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* In the restricted sense explained above.

† Compartive Anatomy of Phanerogams and Ferns. Eng. ed., p. 404.

As the stem advances in age this primary structure is supplemented by the introduction of two additional masses of tissue, in the axile vascular cylinder and the cortex respectively.

i. In the axile vascular cylinder a ring of cambium appears between the primary xylem and the primary phloöm, and gives rise to secondary vascular bundles, the xylem of which forms the 'vascular zone' of Williamson.

ii. In the hypoderma of the cortex another cambium ring makes its appearance, and gives rise to a sclerenchymatous phelloderm, which forms the mechanical tissues of the cortex, the 'prosenchymatous tissues' of Williamson, in a way analogous to that in which phelloderm is formed in existing gymnosperms and phanerogams.

The secondary tissues thus produced, though they may turn out to be essential features of the genus *Lepidodendron*, may be regarded as a part of the adaptations required for the aborescent habit, and need not appear in other genera, which, with *Lepidodendron*, constitute a group of a higher order. In Dicotyledons we have genera and orders in which such secondary structures are constantly present, and others again in which they are constantly absent. Hence there is some justification for regarding the primary tissues of *Lepidodendron* as the only fundamental and characteristic ones, while the secondary tissues are due to adaptative requirements, and for taxonomic purposes must be relegated to the second line.

In this connection it is worthy of note that while the cambium which arises in the vascular cylinder gives rise on the inside to tracheides only, with, of course, medullary rays, that of the hypoderma produces only sclerenchyma. Thus the production of vascular tissue is distinct, and separated in space from that of mechanical tissue, while in Dicotyledons, as is well-known, both forms of tissue arise from the same cambium.

Whether in the case of the secondary vascular bundles, secondary phloëm is produced in any quantity as well as secondary xylem is very doubtful. Similarly, the formation of phelloderm does not appear to have been accompanied by the formation of much phellem or cork, though a little is said to occur in *Lepidodendron selaginoides.*[*]

III. The Leaves.

Speaking generally of the whole group of *Lepidodendreæ*, Schenk[†] states that the leaves are in part like those of the *Lycopodiæ* and *Coniferæ*, linear, pointed, and sometimes of considerable length, as in *L. longifolium*, Brong.; or shorter, as in *L. brevifolium*, Ettingsh.; or again lanceolate, as in *L. Haidingeri*, Ettingsh.; or finally, short and linear, with tips curved inwards as in *L. selaginoides*, Strnbg.

With reference to the leaves of *L. Rhodumneuse*, Solms-Laubach says[‡] that they stand off from the stem at right angles, and then curve upwards like a hook. He adds that the transverse section of the base is rhomboidal, while that of the upper part is crescentic, and that there is a single median vascular bundle. Under which type of bundle this is to be placed has not been definitely determined, some regarding it as collateral and others as concentric.[||]

The leaves of *Lepidodendron* were deciduous, and have left behind the well-known scars and cushions by which the older palæontologists distinguished the various forms from one another. After the fall of the leaf the cushions appear to have grown with the growth of the stem. The leaves being small and closely crowded round the stem on all sides the phyllotaxis is somewhat complicated, though the parastichies are, as a rule, well marked.

IV. The Fruits.

The fruits of *Lepidodendron*, known as *Lepidostrobi*, are cone-like shoot-tips, densely clothed with more or less modified foliar leaves or sporophylls, which bear sporangia containing spores. The outward appearance has some resemblance to the cones of *Lycopodium* and *Selaginella*, though these are extremely diminutive compared with *Lepidostrobi.*

The size of the fruits varies within wide limits as do the individual sporophylls and sporangia, both in size and shape.

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[*] Einleitung in diè Paläophytologie, Von H. Grafen zu Solms-Laubach, p. 227.

[†] Die fossilen Pflanzenreste. Von Dr. A. Schenk p. 60.

[‡] Einleitung in diè Paläophytologie, Von H. Grafen zu Solms-Laubach, S. 222.

[||] Solms-Laubach. Loc. cit., p. 225.

In the sporophyll is a single median vascular bundle, and one can generally distinguish (i.) the peculiarly developed basal portion, to which the sporangia are attached, and (ii.) the lamina, which is usually turned up at a sharp angle over the outer end of the sporangium.

Heterospory is a common phenomena in the fruits of *Lepidodendron.* Binney, Hooker, and others have described specimens in which both macrospores and microspores are present, and others will be found, both figured and described, in Williamson's Memoirs. In the *Lepidostrobus* dealt with by the last-named author in Part III., it is pointed out that the macrosporangia occupy the lower part of the fruit and the miscrosporangia the upper, as is the case with some living species of *Selaginella*, and other investigators have observed the same distribution.

But although heterospory is common, homospory is not unknown, as some fruits have been found in which only microspores are present. Many of these however are but fragments, and hence it is possible that if the whole were at hand the other form of spore might be found. Moreover the possibility that some Lepidodendra were dioecious must not be overloooked, since the knowledge possessed does not enable us to maintain its untenability. Still, without minimising the importance of these considerations, it will be the safer course to regard some of the *Lepidodendra* as being homosporous.

STEM OF LYCOPODIUM.

In all species of the genus *Lycopodium* the stem has the same fundamental structure.

The centre is occupied by an *axile vascular cylinder*, circular in cross section, formed by the fusion of several concentric or radial vascular bundles, and this is surrounded by a relatively thick *cortex*.

The xylem portions of the cylinder consist of small groups of spiral vessels, between which are plates of scalariform tracheides. In fully developed stems the whole vascular cylinder is composed of xylem and phloëm, so that there is no pith.

In *Lycopodium chamacyprissus* the xylem is in the form of ribbons which run more or less parallel to the dorsal surface of the stem, and the course of development of each is centripetal. In species with erect stems, e.g. *L. selago*, the xylem is more symmetrical with respect to the axis, and takes the form of wedge-shaped masses which radiate from the centre and widen outwards.

The phloëm of the cylinder forms a sort of matrix in which the xylem is imbedded. It consists of the usual elements, cells and sieve-tubes, or their homologues, the latter of which have wider lamina than the former. The phloëm is surrounded by a few layers of cells, which form the phloëm sheath, but this, according to Hegelmaier,* seems to correspond with the phloëm-sheath of ferns, and probably belongs to the cortex.

Two or three layers of cells at the innermost periphery of the cortex are differentiated from the rest, and form the 'bundle sheath.' The cells are tangentially compressed, and their walls are somewhat suberized.

As already stated, the cortex is relatively thick, and in several species is readily separable into two layers, though these generally pass gradually the one into the other. These correspond to the hypoderma and inner parenchyma of De Bary, and vary in character in different species, as is indicated below.

At the periphery of the stem, the hypoderma passes over into the tissues of the leaves, which for the most part are not deciduous, and are attached by a broad base.

STEM OF SELAGINELLA.

The stems of plants included in this genus present few varieties of structure, save those found in the vascular tissues and in the number of the vascular bundles.

In *S. Martensii*, there is a single central vascular bundle of the concentric type, and composed of normal xylem and phloëm.

The xylem in cross section is in the form of a flattened ellipse, and consists of two opposite marginal groups of spiral vessels connected by scalariform tracheides. It is developed centripetally from the two opposite points, and does not include a pith.

The phloëm completely invests the xylem, and is composed of parenchymatous cells and sieve-tubes, or their homologues. Enclosing the phloëm is the phloëm-sheath, composed of one, two, or three layers of cells elongated in the longitudinal direction, but as in the case of *Lycopodium* this is probably derived from the cortex.

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* Sachs' Text Book of Botany, 2nd Eng. ed., p. 468.

The stem outside the vascular bundle is made up of a thick cortex, in which we can again distinguish inner parenchyma and hypoderma as in *Lycopodium.* The hypoderma is a thick-walled prosenchymatous tissue, destitute of intercellular spaces, which gradually merges into that of the inner parenchyma. The latter is a thin-walled tissue, destitute likewise of intercellular spaces, save in the immediate neighbourhood of the vascular bundle. Here there occurs a large lacuna or air-cavity, in which the bundle lies, and across which a number of cortical cells run in threads or chains called trabeculæ. As the trabeculæ cross the air-cavity more or less transversely, the cells which compose them are more or less radially disposed, a point to which we shall return.

The air-cavity is not equally well-developed in all species of *Selaginella,* and in some more than a single vascular bundle are normally present.

COMPARISON OF THE STEM TISSUES OF LEPIDODENDRON WITH THOSE OF LYCOPODIUM AND SELAGINELLA.

We now come to the delicate and difficult task of comparing the stems of the three genera whose anatomy and histology have been described so far as seemed material to our purpose. Taking the widest and most general conclusions first the following positions may be assumed as hardly to be contested :—

1. Secondary growth in thickness being absent from *Lycopodium* and *Selaginella,* only the primary tissues of *Lepidodendron,* should in the first instance be brought into comparison with those of the other genera.

2. In all the three genera the surface of contact between the vascular and the fundamental tissues may be held to be separate homologous structures. That is to say, the primary vascular bundles of *Lepidodendron, as a whole,* are homologous with the axile vascular cylinder of *Lycopodium, as a whole,* and with the vascular system of *Selaginella as a whole.* Similarly, the primary cortex of *Lepidodendron* is, *as a whole,* homologous with the entire cortex of *Lycopodium* and that of *Selaginella.* The species of Selaginella which have more

than one vascular bundle offer no objection to this. In them the bundles are isolated, whereas in *Lycopodium* they are fused, but there seems no reason for doubting that the sheaths of fused bundles delimit the same groups of tissue as the sheaths of the bundles themselves.

Assuming that these general homologies will not be contested, the comparison of the stems under consideration may be carried into greater detail. When this is done, it is found that there are certain agreements and differences between them that may be formulated as follows:—

A. LEPIDODENDRON AND LYCOPODIUM.

1. Agreements.
    - i. Both are covered by numerous, relatively small leaves, which are inserted on all sides.
    - ii. Both have an axile vascular cylinder, which has probably arisen by the fusion of a number of vascular bundles.
    - iii. In both, the transverse section of this cylinder is circular, a feature which is doubtless to be correlated with the phyllotaxis, the leaf-trace bundles coalescing with the cylinder on all sides.
    - iv. In *Lycopodium*, the development of the xylem plates is centripetal. This holds also for *Lepidodendron Spenceri*, Will., as described by Williamson in his tenth memoir. The appearance of the primary xylem of other species of *Lepidodendron* suggests the same order of development, but positive proof of this is still wanting. In both genera, however, the smallest elements are at the periphery of the cylinder, and the larger ones internal.
    - v. In young shoots of both *Lepidodendron* and *Lycopodium* the cortex appears homogeneous in composition, the hypoderma being merely distinguishable topographically from the inner parenchyma.
    - vi. In both again, the hypoderma passes gradually into the tissues of the leaf.
2. Differences.
    - i. *Lycopodium* has no pith enclosed within the axile vascular cylinder. The same may be said of *Lepido-*

dendron when in a very young condition, but subsequently a pith is found in the centre, which Williamson describes as becoming more massive as the shoot becomes older.

ii. In *Lycopodium* the cross section of the axile cylinder presents the xylem in the form of a number of distinct bands. In *Lepidodendron* the elements of the xylem are not arranged in distinct bands, and for the most part are in contact laterally as well as radially. Further, the increase in size of the elements, from the periphery inwards, is not nearly so regular as in *Lycopodium.*

iii. In *Lycopodium* the phloëm not only forms the peripheral part of the axile cylinder but is also intercalated between the bands of xylem. In *Lepidodendron* the phloëm appears to be entirely outside the xylem.

iv. *Lycopodium* possesses both a phloëm sheath and a bundle sheath, but these have not yet been found in *Lepidodendron.* Little importance, however, can be attached to this difference until more positive evidence is obtained. It is well within the limits of probability that better preserved specimens than those yet discovered may show the existence of one or more sheathing layers.

v. The matured cortex of most species of *Lycopodium* frequently shows both hypoderma and inner parenchyma more or less sclerenchymatous. This is not the case with *Lepidodendron selaginoides.* Here the inner parenchyma is a soft thin-walled parenchyma, rich in intercellular spaces, and the innermost layers of cells have a radial arrangement. The hypoderma is composed of elements whose walls are somewhat thickened, but as the mechanical function is soon thrown upon the sclerenchymatous secondary phelloderm, the thickening is limited.

B. Lepidodendron and Selaginella.

1. Agreements.

i. In both *Selaginella* and *Lepidodendron* the hypoderma generally consists of more or less thick-walled elements, in which few or no intercellular spaces are met with.

ii. The inner parenchyma, on the other hand, of both genera is composed of thin-walled elements. In *Selaginella* the innermost portion is traversed by an air-cavity surrounding the vascular bundle, across which are stretched cellular filaments whose elements are disposed somewhat radially. A radial arrangement of the cells is very conspicuous at the inner periphery of the inner parenchyma of *Lepidodendron selaginoides*, and this, as well as the position immediately outside the vascular bundle, points to the homology of this layer with the lacunar tissue of *Selaginella*. Some confirmation of this is found in the fact that the foliar bundles of *Lepidodendron* are surrounded by similar radially-arranged rows of cells, while the corresponding bundles of *Selaginella* are enclosed by lacunar tissue.

2. Differences.

i. The centre of the stem of *Selaginella* is occupied by a simple vasular bundle (whether others are present or not), the cross section of which is usually an elongated ellipse. That of *Lepidodendron*, as already stated, is a compound bundle, with a circular transverse section.

ii. The vascular bundle of *Selaginella* has a phloëm sheath, but nothing corresponding to this has yet been observed in *Lepidodendron*.

iii. The vascular bundle of *Selaginella* is surrounded by an air-cavity which is not present in *Lepidodendron*.

TAXONOMIC RELATIONSHIP OF LEPIDODENDRON, LYCOPODIUM AND SELAGINELLA.

In adding a few sentences by way of conclusion on the taxonomic relationships of these genera, it may be well to say at the outset, that we accept Williamson's view of the Lycopodiaceous affinities of *Lepidodendron* as one which now rests on a sound scientific basis. In other words we are satisfied that the place of *Lepidodedron* is somewhere in the group now termed Lycopodineæ. But whether, in that group, it should stand nearer to *Lycopodium* than *Selaginella* or *vice versa*, is not so certain.

Goebel* divides the Lycopodineæ into three series, viz., *Lycopodiaceæ, Psilotaceæ* and *Ligulatæ,* and classifies *Lepidodendra* as heterosporous *Lycopodiaceæ.*

Van Tieghem,† on the other hand, divides the *Lycopodineæ* into two orders, homosporous and heterosporous, and places *Lepidodendron* in the latter, along with *Isoetes* and *Selaginella.*

Thus while both agree to ignore the view that some *Lepidodendra* were homosporous, one attaches weight to the characters in which they agree with *Lycopodium,* and the other to those in which they agree with *Selaginella.* That *Lepidodendra selagnioides* does unite within itself anatomical and other features which *Lycopodium* and *Selaginella* divide between them is shown by the detailed comparison given above. The axile vascular cylinder and the correlated phyllotaxis approximate to those of *Lycopodium,* while the cortical tissues and the heterosporous fruits of some come nearer to those of *Selaginella.* It is difficult however to evaluate the rival claims of these similarities and differences. In our judgment the agreement of the vascular tissues is not of itself sufficient to warrant the association of *Lepidodendron* with *Lycopodium* as is done by Goebel; nor on the other hand are the heterosporous fruits and the cortical resemblances sufficient to ally it with *Selaginella* as is done by Van Tieghem. Probably the most that can be said, is, that the three genera have been derived through a series of intermediate forms from some common homosporous ancestor, from whom their common features have been inherited. But even on this hypothesis the facts at our command throw little light on the relationships of the diverging branches, and on their relative positions on the parent stock. We submit therefore, that until more precise knowledge bearing upon the affinities of these genera is obtained, and keeping in mind that homospory has not yet been positively disproved in *Lepidodendron,* the grouping of the Lycopodineæ should be somewhat as follows:—

Lycopodineæ.
- *a.* Lycopodiaceæ.
- *b.* Psilotaceæ.

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[*] **Outlines of Classification and Special Morphology.**

[†] **Traité de Botanique.**

c. Ligulateæ.
d. Lepidodendreæ.
  1. Homosporous Lepidodendreæ.
  2. Heterosporous Lepidodendreæ.

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FOSSIL FISH-REMAINS FROM CARBONIFEROUS SHALES AT CULTRA, CO. DOWN, IRELAND. BY JAMES W. DAVIS, F.G.S.

Some time ago I received a small collection of fossil fish-remains collected from the dark carboniferous shales at Cultra, Co. Down, in Ireland, by Mr. Chas. Bulla, of Belfast. The majority of the specimens are somewhat fragmentary and difficult to determine, but there are others which appear to add to the already rich fauna of the

Carboniferous series of that country. The latter consists of two spines and a number of bony plates of a species of Cœlacanthus.

In 1881, in a paper read at the Geological Society (Quarterly Journal, vol. xxxvii., p. 427), I described a number of spines obtained from the Cannel Coal at Tingley and the Lower Limestone series near Edinburgh. Similar in form to some members of the genus Pleuracanthus, they were readily distinguished by the entire absence of lateral or posterior rows of denticles. For these spines the generic name Anodontacanthus was suggested. They were straight and gradually contract in diameter towards the apex, which is more or less pointed. An internal cavity, wide at the base, extends nearly the whole length of the spine; from its resemblance to the form of the spine of Pleuracanthus, it is probable that the spine of Anodontacanthus was implanted in the same manner, possibly in a similar position behind the occipital region of the head, as in that genus. The fish spines from Cultra possess the generic characters of Anodontacanthus, they are straight and tapering, the internal cavity opens terminally, and they are without denticles. They are much more slender in proportion to their length, but this feature can only be regarded as of specific importance.

Anodontacanthus attenuatus, Davis, sp. nov.

Spine: length preserved 1·8 inches; width near the base 0·1 inch, decreasing towards the apex, which is half the diameter of the base. The spine is straight, circular near the base, laterally depressed, with a slight median groove towards the apex; its surface is divided by a series of small ridges which present a slightly imbricated appearance, between the ridges the surface is smooth. An internal cavity extended through the whole length of the spine, so far as these specimens exhibit it, unfortunately the upper termination is defective.

This species differs from the species already described in its elongated form and attenuated aspect. From *Anodontacanthus obtusus* and *A. fastigiatus* it may be distinguished by its round section near the base, those species being oval, and from *A. acutus,* which is uniformly round, it is readily recognised by the depressed and channelled lateral surface towards the apex. The ridges ornamenting its external surface also serve to separate this form from those previously described. Having reference to its long and slender outline the specific name of *A. attenuatus* is suggested to distinguish this species.

Cœlacanthus, sp.

Several bones of Cœlacanthus have been found. Those most readily distinguishable are the operculum, a jugular plate, frontal bones of the external surface of the head, and a portion of the shoulder girdle. With the exception of the jugular bone they are all exposed on the under surface. The jugular plate has the external surface exposed: it possesses the characteristic ornamentation of the genus.

The plates of Cœlacanthus were found associated with a number of scales of moderate size, said to be a species of Holoptychius: I have not seen them.

SECRETARY'S REPORT.

During the past year there has been an addition of nine new members, the total number now being 219. Of these five are honorary members, and thirty-six have compounded for their annual subscriptions and become life members.

The Society has met three times during the year, the Annual Meeting being included. A meeting was held in May at Malton, when Mr. J. H. Phillips, of Scarborough, presided, and papers were read by Mr. G. W. Lamplugh and the Honorary Secretary. A second meeting was held on August 14th, at Hickleton, near Doncaster, when the members present were entertained by one of the Vice-Presidents, Lord Halifax, who also presided at the meeting. Seven new members were elected, and Mr. T. W. H. Mitchell, C.E., was elected local secretary for Barnsley. Eight papers were read, the one by Professor Arnold Lupton being illustrated by the oxy-hydrogen light; the others were by Revs. J. Stanley Tute and E. Maule Cole, Messrs. William Cheetham, J. R. Mortimer, T. Carter Mitchell, and and George R. Vine.

A sum of five pounds was voted from the funds of the Society, to be presented to Mr. G. R. Vine to enable him to prosecute his original researches in Fossil Polyzoa.

The Annual Meeting was the third, and was held in the rooms of the Philosophical Society, Leeds. The president, the Marquis of Ripon, occupied the chair, and the usual business of the annual meeting was transacted. The President gave an address, and papers were read by Messrs. C. E. De Rance, G. R. Vine, T. Tate, G. W. Lamplugh, Hick and Cash, and Rev. E. Jones.

To the following list of Local Secretaries must be added the the name of Mr. T. W. H. Mitchell, C.E., who has kindly undertaken the office for the Barnsley district.

Bradford	**Thos. Tate, F.G.S., 5, Eldon Mount, Leeds**
Bridlington	**G. W. Lamplugh, Bridlington Quay**
Driffield	**Rev. E. Maule Cole, M.A., Wetwang**
Halifax	**Geo. Patchett, Junr., Halifax**
Harrogate	**R. Peach, Harrogate**
Huddersfield	**P. Sykes, 33, Estate Buildings, Huddersfield**

Leeds...	S. A. Adamson, F.G.S., 52, Well Close Terrace, Leeds
Leyburn and Wensleydale	W. Horne, F.G.S., Leyburn
Thirsk	W. Gregson, Baldersby, Thirsk
York	H. M. Platnauer, The Museum, York.

The Society is much indebted to these gentlemen for their continued interest in its welfare.

The proceedings and memoirs of the learned Societies, whose names are appended, are forwarded to this Society ; in exchange, our proceedings art sent to them. The thanks of the Society are due and hereby tendered to those Societies for their respective contributions.

Essex Naturalists Field Club
Norwich Geological Society
Memorias de la Sociedad Cientifica “ Antonio Alzate ” Mexico
Yorkshire Archæological and Topographical Society
Warwickshire Natural History and Archæological Society
Royal Society of Tasmania, Van Dieman's Land
Royal Dublin Society
Royal Academy of Science, Stockholm, Sweden
Geological Association, Liverpool
Royal Historical and Archæological Association of Ireland
Geologists' Association, London
Manchester Geological Society
Literary and Philosophical Society, Liverpool
Royal Institution of Cornwall
Royal Geological Society of Ireland
Midland Naturalist, Birmingham
Academy of Natural Sciences, Philadelphia, U.S.A.
Naturhistorischen Hofmuseum, Wien, Austria
Societie Imperiale des Naturalistes, Moscow
United States Geological Survey of the Territories, Washington
Boston Society of Natural History, U.S. America
Hull Literary and Philosophical Society
Connecticut Academy of Arts and Sciences
Academy of Science, St. Louis, U.S. America
Historical Society of Lancashire and Cheshire
Geological Society of London
Royal University of Norway, Christiana
Sociètè-Geologique du Nord, Lille
Royal Society of Edinburgh
Royal Geological Society of Cornwall

Royal Physical Society of Edinburgh
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club
Birmingham Natural History and Microscopical Society
Bristol Naturalists' Society
Leeds Geological Association
Patent Office Library, London
Powis Land Naturalists' Club, Aberystwith
American Philosophical Society, Philadelphia, U.S.A.
Comité Geologique de Russie, St. Petersburg
Elisha Mitchell Scientific Society, Chapel Hill. U.S. America

The Jubilee History of the Society has been completed and issued to the Members without extra charge. It may be reasonably hoped that interest in the Society will be engendered and that an increase in the number of members may be one result of the publication. It is very desirable that the income of the Society, and consequently the number of its members, should be increased; the amount and quality of its work is influenced by the funds the Council have at their disposal for printing and illustration.

The exploration of the ancient Sea-beach at Sewerby, near Bridlington, has been discontinued, so as to afford an opportunity to the sea to wash away all the detritus removed from the part exposed. The large series of bones obtained during the investigation are in process of gelatinization by Mr. Lamplugh at Bridlington.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society, 1888-9.

Receipts.

	£	s.	d.
To Balance in hands of Treasurer, Oct. 31st, 1888	15	15	8
,, Subscriptions	80	11	9
,, Interest on Halifax Corporation Bonds	11	13	2
	£108	0	7

Expenditure.

	£	s.	d.
By Whitley and Booth	30	0	0
,, Geo. R. Vine	5	0	0
,, Expenses at Meetings (including Jubilee Meeting)	14	12	4
,, Meisenbach & Co.	2	12	0
,, Postage	4	7	2
,, Balance in hands of Treasurer ...	51	9	1
	£108	0	7

CAPITAL ACCOUNT.

	£	s.	d.
To Halifax Corporation Bond	350	0	0
,, Cash in hands of Treasurer	12	12	0
	£362	12	0

WM. CASH, Treasurer,

29th October, 1889.

MINUTES OF MEETINGS.

Council Meeting, Philosophical Hall, Leeds, April 10th, 1889.

J. Ray Eddy, Esq., in the chair; present—Messrs. Reynolds, Cheetham, Bedford, Adamson, Gray and Davis.

The minutes of the last meeting were read and confirmed.

The following account was ordered to be paid :—

Halifax Literary and Philosophical Society	2s. 6d.

The Hon. Secretary presented a copy of the History of the Society, and it was resolved on the motion of Mr. Cheetham, seconded by Mr. Bedford,—

That the volume be bound in cloth.

Mr. Reynolds proposed, and Mr. Bedford seconded,—

That copies be supplied to members without charge before the end of the current year, and that extra copies may be supplied to members at a charge of 5s. each.

It was resolved that a meeting be held as soon as possible in May, and that the Secretary make the necessary arrangements for it.

General Meeting, Talbot Hotel, Malton, May 8th, 1889.

J. H. Phillips, Esq., occupied the chair.

The minutes of the annual meeting were read and confirmed.

The following papers were read :—

G. W. Lamplugh, "On the sequence of the Beds at Speeton and their foreign equivalents."

The paper was discussed by the Chairman, Rev. E. Maule Cole, and Mr. Davis.

James W. Davis, "On a Biographical notice of Hugh E. Strickland, F.G.S., &c."

A vote of thanks to the Chairman terminated the proceedings, the authors of papers being also included.

Meeting of the Council, Leeds, July 10th, 1889.

Richard Carter, Esq., in the chair; present—Prof. A. Lupton, Messrs. Rowley, Atkinson and Davis.

The minutes of last meeting were read and confirmed. A correspondence between the Hon. Secretary and Lord Halifax was read, and it was resolved on the motion of the Chairman, seconded by Mr. Rowley,—

That the invitation of Lord Halifax to meet at Hickleton be accepted, and that the meeting be held at 3-0 p.m. on August 14th.

It was resolved that papers be accepted from Prof. A. Lupton, Mr. G. R. Vine, Rev. J. S. Tute, and Mr. W. Cheetham.

A letter from Mr. G. R. Vine was read by the Hon. Secretary, and on the motion of Mr. Atkinson, seconded by Mr. Lupton, it was resolved,—

That the Society be recommended at its next general meeting to make a grant from its funds to Mr. Vine, to assist him in the prosecutions of his researches on the Fossil Polyzoa.

Mr. Atkinson proposed, the Chairman seconding,—

That this Council, at the [first meeting since the publication of the History of this Society, begs to thank the Honorary Secretary, Mr. Davis, for the very able manner in which he has compiled and edited it, the resolution was carried.

General Meeting at Hickleton, the residence of Viscount Halifax, Vice-President, August 14th, 1889.

The chair was occupied by Viscount Halifax.

The minutes of the last meeting were read and confirmed.

The Honorary Secretary proposed, and Mitchell seconded, and it was carried unanimously—

That the following gentlemen be admitted members of the Society :—

Matthew Stephenson, Esq., Queen's Road, Harrogate.
Rev. W. Travis Travis, M.A., Rector of Ripley, Yorkshire.
Jno. Lister, Esq., M.A., Shibden Hall, Halifax.
M. Nicholson, Esq., J.P., Middleton Hall, Leeds.
Michael Stocks Junr., Esq., Shibden Head, Halifax.
H. St. John Durnford, Esq., Swaithe, near Barnsley.
J. C. Thompson, Esq., Solicitor, Selby.

Proposed by the Honorary Secretary, seconded by Mr. R. Sugden,

That T. W. H. Mitchell, Esq., C.E., &c., be elected the Honorary Local Secretary for Barnsley. Carried.

Proposed by J. T. Atkinson, Esq., and seconded by Rev. J. S. Tute, that a grant from the Society's funds of £5 be made to Mr. G. R. Vine, of Sheffield, in recognition of his valuable researches in the Fossil Polyzoa, and to assist him in further prosecution of his work. Carried with acclamation.

The Chairman gave an address.

The following papers were read :—

"Notes on the Burrows of a Stone-boring Shell-fish in the Permian Sandstone." By Rev. J. Stanley Tute, B.A.

"On a Boulder with cup and ring markings, found at Horsforth, near Leeds." By W. Cheetham, F.G.S.

"Notes on Gold, Salt, and Slate Mines in Great Britain," illustrated by the oxy-hydrogen lantern. By Professor A. Lupton, C.E., F.G.S., &c.

"On the Pre-History of the village of Fimber." By J. R. Mortimer, F.G.S.

"On the Boulders of the Drift near Thirsk." By T. Carter Mitchell.

"Monograph on the Yorkshire Carboniferous Polyzoa, Part II." By Geo. R. Vine.

"Notes on British Eocene Polyzoa." By Geo. R. Vine.

"Notes on the new line of Railway from Market Weighton to Driffield." By Rev. E. Maule Cole, M.A., &c.

The last paper was deferred to a future meeting on account of the lateness of the hour.

Mr. J. T. Atkinson proposed a vote of thanks to the Chairman and the contributors of papers, seconded by Mr. M. Nicholson.

Meeting of the Council, Museum, Leeds, October 23rd, 1889.

Mr. J. T. Atkinson in the chair.

Present :—Messrs. Atkinson, Bedford, Gray, Davis, Cheetham, Bedford, Carter, Embleton, Parke, Tate, Reynolds, Adamson, and Prof. Lupton.

The minutes of the last meeting were read and confirmed.

The following accounts were ordered to be paid on the motion of Mr. Cheetham, seconded by Mr. Gray :—

		£	s.	d.
Whitley & Booth	... ...	23	6	0
Do.	... ...	101	15	6

On the motion of Mr. Atkinson, seconded by Mr. Carter, the arrangements for the annual meeting to be held at Leeds, on Wednesday, 30th October, made by the Honorary Secretary be confirmed; that the Marquis of Ripon occupy the chair, and papers be accepted from Messrs. De Rance, Vine, Tate, Lamplugh, Hick, and Rev. E. Jones.

It was also resolved that the members dine at the conclusion of the meeting at the Queen's Hotel.

Mr. G. H. Parke proposed, Mr. Carter seconded, and carried,—

That the Leeds Geologists' Association be invited, through their Secretary, to be present at the annual meeting.

Mr. T. W. Embleton, through the Honorary Secretary, presented to the Society a large amount of matter relating to its earlier years which were of great assistance to the Honorary Secretary in the preparation of the History of the Society recently published, whereupon it was resolved on the motion of Mr. T. Tate, F.G.S., seconded by Mr. G. H. Parke, F.G.S.,—

That the best thanks of the Society be tendered to Mr. Embleton for his valuable gift.

Annual Meeting held at the Museum, Leeds, on Wednesday, October 30th. 1889.

The President the Marquis of Ripon in the chair.

The Hon. Secretary read the Minutes of the last General Meeting which were confirmed.

The Hon. Secretary read the Annual Report and made a financial statement which was approved.

On the motion of Mr. R. Carter, seconded by Mr. T. W. Embleton, the Marquis of Ripon, K.G., was re-elected President for the ensuing year.

On the motion of Mr. Davis, seconded by Mr. Atkinson, the Vice-Presidents were re-elected.

Mr. W. Cheetham proposed and Mr. W. Rowley seconded, and it was carried, that Mr. James W. Davis be re-elected Hon. Secretary, and that Mr. Wm. Cash be re-elected Treasurer.

On the motion of the Rev. J. Stanley Tute the Members forming the Council were re-elected.

Mr Davis moved and Mr. Eddy seconded that Mr. J. T.

Wilkinson, Burnside, Skipton, be elected a Member of the Society, carried.

The Marquis of Ripon, after thanking the members for his re-election, gave an address.

The following Papers were read:—

Chas. E. de Rance, F.G.S., "Notes on the Underground Water Supply and River Floods."

The Chairman, Mr. Davis and Mr. Embleton spoke on the paper.

G. R. Vine, "On the Polyzoa of the Cambridge Greensand."

Thos. Tate, F.G.S., "Part II. of Yorkshire Petrology."

G. W. Lamplugh, "Report on the Boulders of Flambro' Head."

Thos. Hick, B.A., B.Sc., &c., and Wm. Cash, F.G.S., &c., "On the structure and affinities of Lepidodendron."

Rev. E. Jones, "Further account of the investigation of Elbolton Cave, near Skipton."

G. W. Lamplugh, "Glacial Section near Bridlington."

A vote of thanks to the chairman and the authors of papers concluded the meeting.

The members afterwards adjourned to the Queen's Hotel and dined.

SUMMARY OF GEOLOGICAL LITERATURE RELATING TO YORKSHIRE, PUBLISHED DURING 1889.

Compiled by JAMES W. DAVIS.

ANON. On the Investigation of British Barrows, near Hunmanby, in the East Riding. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. xi., p. 91.

BINNIE, W. J. E. The Mesozoic Rocks of the North-east Coast of Ireland. *Proc. Yorksh. Geol. and Polyt. Soc*, vol. xi., p. 53.

COLE, Rev. E. MAULE. Notes on the Ancient Entrenchments in the neighbourhood of Wetwang. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. xi., p. 45.

——— ——— On a Lake Dwelling recently discovered at Preston. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. xi., p. 90.

DE RANCE, C.E. Notes on the Vale of Clwyd Caves. *Proc. Yorksh. Geol. and Polyt. Soc.*, N.S., vol. xi, p. 1.

DAVIS, JAMES W. On the Lake Dwellings in East Yorkshire. *Proc. Yorksh. Geol. and Polyt. Soc.*, N.S., vol. xi., p. 101.

JONES, Rev. E. On the Recent Exploration of a Cave at Elbolton, near Thorpe. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol xi., p. 86.

LAMPLUGH, G. W. On the Subdivisions of the Speeton Clay. *Quart. Jour. Geol. Soc.*, vol. xlv., p. 575.

McLANDSBOROUGH, J. and A. E. PRESTON. Meteorological Tables. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. xi., p. 137.

RIPON, MARQUIS of. On the Future Extension of the Society. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. xi.. p. 114.

SPENCER, JAMES. On the Occurrence of a Boulder of Granitoid Gneiss, or Gneissoid Granite, in the Halifax Hard Bed Coal. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. xi., p. 96.

VINE, G. R. Notes on the Classification of the Palæozoic Polyzoa. *Proc. Yorksh. Geol. and Polyt. Soc.*. vol. xi., p. 20.

——— ——— A Monograph of Yorkshire Carboniferous and Permian Polyzoa. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. xi., p. 68.

WOODWARD, A. S. Palæontology in the Malton Museum. *Geol. Mag.*, No. 302, p. 361.

LIST OF MEMBERS.

Life members who have compounded for their annual subscriptions are indicated by an asterisk (*).

HONORARY MEMBERS.

Bodington, Principal N., M.A., &c., The Yorkshire College, Leeds.
Hughes, Prof. T. McK., F.R.S., &c., Cambridge.
Judd, Prof. Jno. W., F.R.S., Science Department, South Kensington, London.
Williamson, Prof. W. C., F.R.S., Owen's College, Manchester.
Woodward, Henry, Esq., L.L.D., F.R.S., British Museum, (Natural History), London, S.W.

---

*Abbott, R. T. G., Quarry Cottage, Norton, Malton.
Adamson, S. A., F.G.S., 52, Well Close Terrace, Leeds.
*Aldam, W., J. P., Frickley Hall, Doncaster.
Atkinson, J. T., F.G.S., Hill Field House, Selby.

Bailey, Geo., 22, Burton Terrace, York.
Baines, Sir Edward, J.P., St. Ann's, Burley, Leeds.
Balme, E. B. W., J.P., Cote Hall, Mirfield.
Bartholomew, Chas., Castle Hill House, Ealing, Middlesex.
*Bartholomew, C. W., Blakesley Hall, near Towcaster.
Bayley, Rev. T., Weaverthorpe.
Beaumont, Hy., Elland.
Bedford, James, Woodhouse Cliff, Leeds.
Bedford, J. E., Clifton Villa, Cardigan Road, Leeds.
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Binnie, A. R., F.G.S., M. Inst. C.E., Town Hall, Bradford.
Binns, J. A., 11, Oak Lane, Manningham.
*Booth, James, F.G.S., Springhall, Halifax.
Bould, Chas. H., Halifax Old Road, Huddersfield.
*Bowman, F. H., D.Sc., F.R.A.S., F.C.S., F.G.S., Halifax.
Bradley, George, Aketon Hall, Featherstone.

Brierley, H. G., Glen View, Huddersfield.
*Brigg, John, J.P., F.G.S., Keighley.
*Briggs, Arthur, J.P., Cragg Royd, Rawden, Leeds.
Briggs, Riley, Osgodby Hall, Selby.
Broadhead, John, St. John's Colliery, Normanton.
Bromley, J. Harrison, 14, Lodge View, Tong Road, Leeds.
Brooke, Ed., jun., F.G.S., Fieldhouse Clay Works, Huddersfield.
Brooke, Lieut.-Col. Thos. J.P., Armitage Bridge, Huddersfield.
Brownridge, C. C E., F.G.S., Horsforth, Leeds.
*Buckley, George, jun., Waterhouse Street, Halifax.
Butler, J. Dyson, Estate Buildings, Huddersfield.

Carter, Jas., Burton House, Bedale.
Carter, R., C.E., F.G.S., Springbank, Harrogate.
*Cash, W, F.G.S., Elmfield Terrace. Halifax.
Chadwick, Wm,, Arksey, Doncaster.
*Charlesworth, J. B., J.P., Wakefield.
Cheetham, W., Horsforth, near Leeds.
*Clark, J. E., B.A., B.Sc., F.G.S., 20, Bootham, York.
Cole, Rev. E. Maule, M.A., Wetwang Vicarage, near York.
Critchison, Rev. J., Elland, Halifax.
Crossley, Lieut.-Col. Louis J., J.P., F.R.M.S., Moorside, Halifax.
Crowther. F., Northowram, near Halifax.

*Dakyns, J. R., M.A., of H.M. Geological Survey. 28, Jermyn Street, London, W.
Dalton, Thos., Albion Street, Leeds.
Dartmouth, Earl of, Patshull House, Wolverhampton.
Davidson, J., F.C.S., Holywell Green, near Halifax.
*Davis, James W., F.S.A., F.G.S., F.L.S., Chevinedge, Halifax.
Davis, R. Hayton, F.C.S., Harragate.
Dawson, Oswald. Caledonian House, Leeds.
*Denham, Charles, London.
Dewhurst, J. B., Aireville, Skipton.
Dobson, M. G., Stannary Hall, Halifax.
Dodsworth, Sir Charles, Bart., Thornton Watlass, Bedale.
Dolan, T. M., M.D., Horton House, Halifax.

Drury, Ed., Halifax.
*Duncan, Surr W., Horsforth Hall, Horsforth, near Leeds.
Durnford, W. St. John, Swaithe, near Barnsley.

Eddy, J. Ray, F.G.S., Carleton Grange, Skipton.
Effingham, Earl of, Tusmore House, Bicester.
Embleton, T. W., The Cedars, Methley.
Emmott, W., The Square, Halifax.

Farrar James, Old Foundry, Barnsley.
Fennel, Chas. W., Westgate, Wakefield.
Field, Joseph, West Parade, Halifax.
Filleter, E., F.G.S., M. Inst. C.E., East Parade, Leeds.
Fitzwilliam, Earl, K.G., Wentworth Woodhouse, near Rotherham.
*Fleming, Francis, Elm Grove, Halifax.
Fox, M., jun., Mirfield,

Galway, Viscount, Selby Hall, Bawtry.
Garforth, W. E., C.E., F.G.S., Normanton.
Gascoigne, Col. T., Parlington Park, Garforth, near Leeds.
*Gaukroger, W., Fernside, Halifax.
Gleadhow, F., Sutton, near Alford, Lincolnshire.
Gough, W. C., Wykeham, York,
*Gray, Thos. H., Brookleigh, Calverley, Leeds.
Greaves, J. O., Wakefield.
*Green, Prof. A. H., M.A., F.G.S., 137, Woodstock Road, Oxford.
Gregson, W., Baldersby, Thirsk.

Hailstone, E., F.S.A., Walton Hall, Wakefield.
Halifax, Viscount, Hickleton Hall, Doncaster.
Hallilay, J., Burley Road, Leeds.
Hanstock, John, Denby Grange, near Wakefield.
Harding, E., Bridlington Quay.
Harrison, George, East View, Huddersfield.
Harry, E. Wareham, C.E., Borough Engineer, Harrogate.
Hastings, Godfrey, 16, Neal Street, Bradford.
Hawell, Rev. Jno., Ingleby Greenhow, Northallerton.
*Helliwell, T. W., Brighouse.

HESLINGTON, T. C., North Road, Ripon.
HEWITSON, H. B., 11, Hanover Place, Leeds.
HOLGATE, BENJ., F.G.S., Regent House, Grosvenor Road, Headingley, Leeds.
HOLROYD, A., Savile Park, Halifax.
HOLT, H. P., C.E., F.G.S., Fairlea, Didsbury, Manchester.
HORNE, WM., Leyburn.
HOUGHTON, LORD, Fryston Hall, near Pontefract.
*HUDDLESTON, W. H., Culverden Lodge, Oaklands Park, Weybridge.
HUNT, H. J., Surgeon, Harrogate.

JACKSON, Rev. E., Manningham, Bradford.
JONES, Rev. E., Rockville, Embsay, Skipton.
JONES, J. E., Solicitor, Halifax.
JURY, SAMUEL, Halifax Old Road, Huddersfield.

*KERR, R. MOFFATT, Solicitor, Halifax.
KIRBY, JOEL, Mexborough.
KNOWLES, G.,

*LAMPLUGH, G. W., F.G.S., Wellington Road, Bridlington Quay.
LANCASTER, ED., Barnsley.
LAURENCE, JNO., Barnsley.
LAXTON, F., Rastrick, Brighouse.
*LEACH, JOHN, Park Road, Halifax.
LEAROYD, S., F.G.S., Sherwood House, Huddersfield.
LEEDS, Duke of, Hornby Castle, Bedale (care of S. T. Jones, Hornby Castle Office, Bedale).
LISTER, JOHN, M.A., Shibden Hall, Halifax.
LOWTHER, Sir CHARLES, Bart., Swillington Park, near Leeds.
LUPTON, ARNOLD, F.G.S., M. Inst. C.E., 6, De Grey Road, Leeds.
LUKIS, Rev. W. C., M.A., &c., The Rectory, Wath, near Ripon.
LUND, PERCY, Ilkley.

MARSDEN, THOMAS, Paper Mills, Barnsley.
MARSHALL, JOHN, F.G.S., Walsden, Todmorden.
MASON, C. L., Leeds.

McLandsborough, J., F.G.S., F.R.A.S., &c., Manningham, Bradford.
Middleton, Charles, Lord Street, Halifax.
Milne, S. Milne, Calverley House, near Leeds.
Mitchell, John, Swaith Hall, near Barnsley.
Mitchell, Josh., F.G.S., Worsbro' Dale, Barnsley.
Mitchell, T. Carter, Topcliff, Thirsk.
Mitchell, T. W. H., Barnsley.
Morley, George, Garforth, near Leeds.
*Morrison, Walter, M.P., Malham Tarn, near Leeds.
Mortimer, J. R., F.G.S., Driffield.
Morton, H. J., 2, Westbourne Villas, Scarborough.
*Myers, W. Beswick, 75, Avenue Road, Regent's Park, London, N.W.

Nelson, Henry, St. John's Cottage, St. John's Road, Leeds.
*Nicholson, M., Middleton Hall, near Leeds.
Norton, Walter, J.P., Denby Dale, Huddersfield.

Ormerod Hanson, Boothroyd, Brighouse.
Ormerod, Thomas, Fulham, London.

Parke, G. H., F.G.S., F.L.S., College Grove Road, Wakefield.
Paul, Geo., F.G.S., York.
Parsons, H. Franklin, M.D., F.G.S., 13, Whitworth Road, South Norwood, London, S.E.
Patchett, George, junior, Halifax.
Peach, Robert, Harrogate.
Platnauer, H. M., F.G.S., The Museum, York.
Pocklington, Henry, F.R.M.S., Park Row, Leeds.
Pole, Charles, Halifax.
Pole M., H.M. Inspector of Schools, Sowerby Bridge, Halifax.
Pollock, Rev. Dr., Cundall Vicarage, Boroughbridge.
Preston, Alfred Eley, C.E., F.G.S., The Exchange, Bradford.

*Ramsden, Sir J. W., Bart., M.P., Byram Hall, near Pontefract.
Reynolds, Richard, F.C.S., Cliffe Lodge, Leeds.
Rhodes John, Snydale Hall, Pontefract.
Rigge, S. T., F.S.A., Balmoral Place, Halifax.

*Ripon, The Marquis of, K.G., F.R.S., &c., Studley Royal, Ripon.
Rollitt, Sir A. K., LL.D., D.C.L., Cogan House, Hull.
Ross, James, Harrogate.
Rowley, Brook, Weymouth Street, Halifax.
*Rowley, Walter, F.G.S., Albion Street, Leeds.
*Ryder, Charles, Westfield, Chapeltown, Leeds.

Saddler, M. T., M.D., Barnsley.
Scarborough, Geo., Whinney Field, Halifax.
Scarborough Philosophical Society, J. I Phillips, (Scarborough)
Scratcherd, T. H. C., Halifax.
Seal, Henry, Vale Head, Knottingley.
Seal, Stephen, F.G.S., Darfield Quarries, Barnsley.
Sharp, C. Forbes, Driffield.
Shaw, John, Darrington Hall, Pontefract.
Shaw, Thomas, M.P., D.L., J.P., Allangate Halifax.
Sladen, W. P., F.G.S., F.L.S., Orsett House, Ewell, Surrey.
Slater, E., Ashville, Stanningley, Leeds.
Slater, M. B., Malton.
Slingsby, W. C., Carleton, near Skipton.
Smith, F., Huddersfield Road, Halifax.
Sorby, H. C., D.C.L., F.R.S., F.G.S., Broomhill, Sheffield.
Stanhope, W. T. W. S., J.P., Cannon Hall, Barnsley.
*Stansfeld, A. W., Westgrove, near Leeds.
Steel, R. Elliott, M.A., Spring Cliff House, Heaton Road, Bradford.
Stephenson, M., Queen's Road, Harrogate.
*Stockdale, T., Spring Lea, Leeds.
Stocks, Michael, junior, Shibden Head, Halifax.
Stott, W., Greetland, near Halifax.
Strangways, C. Fox, F.G.S., of H.M. Geological Survey, 5, Belgrave Crescent, Scarborough.
*Strickland, Sir Charles W., Bart., Hildenley, Malton.
Sugden, Richard, ye Farre Close, Brighouse.
Swallow, D., Gas Works, Bradford.
Sykes, Peace, 33, Estate Buildings, Huddersfield.
Sykes, Sir Tatton, Bart., Sledmere House, near York.

Tate, Thomas, F.G.S., 5, Eldon Mount, Leeds.
Taylor, Jas., Borough Surveyor, Barnsley.
Taylor, J. D., Halifax.
Tennant, J. R., 62, Brunswick Place, Brighton.
Tetley, Mrs., Foxhills, Weetwood, Leeds.
Tetley, C. F.. M.A., Spring Road, Headingley Leeds.
*Tew, Thomas, W., J.P., Carleton Villa, near Pontefract.
Travis, Rev. W. Travis, Ripley.
Thompson, J. C., Selby.
Thompson, R., Park Street, The Mount, York.
*Tiddeman, R. H., M.A., F.G.S., of H.M. Geological Survey, 28, Jermyn Street, London.
Townend, Walter, Huddersfield.
Turner, R. Bickerton, J.P., Oak Leigh, Buxton.
Tute, Rev. J. Stanley, B.A., Markington, Ripley.

Utley, Samuel, Halifax.
Utley, William, Halifax.

Veitch, W. Y., M.D., 37, Grange Road, Middlesborough.
Vine, George, R., 112, Hill Top, Attercliffe, Sheffield.

*Walmisley, A. T., C.E., F.S.I., F.K.C., 5, Westminster Chambers, Victoria Street, London.
*Ward, J. Whiteley, J.P., F.R.M.S., South Royd, Halifax.
Ward, John, F.G.S., 23, Stafford Street, Longton, Staffordshire.
Wharncliffe, Earl of, Wortley Hall, Sheffield.
Wheatley, Charles, Sands House, Mirfield.
*Whiteley Fredk., Clare Road, Halifax.
Wilkinson, J. J., Skipton.
Wilson, E. J., M.A., 6, Whitefriars' Gate, Hull.
Woodall, J. W., J.P., F.G.S., Old Bank, Scarborough.
Woodhead, Joseph, M.P., J.P., Woodthorpe, Huddersfield.

⁂ It is requested that Members changing their residence will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1889.

SHEET 1.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, M Inst. C.E. retired, F.R.A.S., F.R.Met.Soc., F.G.S., and Alfred Eley Preston, M. Inst. C.E., F.R.Met.Soc., F.G.S.
Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

Months.	Pressure of Atmosphere in Month: Highest Reading of Barometer	Date	Mean of Highest of 21 Years	Lowest Reading of Barometer	Date	Mean of Lowest of 21 Years	Range	Corrected for Capillarity and Temperature: Mean	Corrected for Capillarity and Temperature: Mean of 21 Years
	Ins	On	Ins	Ins	On	Ins	Ins	Ins	Ins
January	30 336	3rd	30 181	28 896	9th	28 696	1 440	29 687	29 524
February	30 025	19th	30 079	28 728	3rd	28 779	1 297	29 462	29 502
March	30 235	15th	30 137	28 460	20th	28 771	1 775	29 538	29 499
April	29 824	19th	30 065	28 815	4th	28 829	1 009	29 329	29 472
May	29 852	20th	30 056	29 234	28th	29 031	0 618	29 431	29 549
June	30 180	5th	30 134	29 428	2nd	29 178	0 752	29 683	29 562
July	30 134	1st	29 973	29 120	25th	29 050	1 014	29 530	29 519
August	29 914	31st	29 982	28 802	20th	29 063	1 112	29 421	29 508
September	30 120	15th	30 085	29 220	20th	28 977	0 900	29 614	29 513
October	29 979	25th	30 119	28 483	7th	28 729	1 496	29 480	29 451
November	30 322	17th	30 042	29 035	25th	28 683	1 287	29 772	29 446
December	30 358	5th	30 114	28 857	10th	28 666	1 501	29 718	29 470
Means, or totals	30 106		30 070	28 923		28 879	1·183	29 539	29 500

Months.	Temperature of Air in Shade during Month, In Each Month: Highest	Date	Mean of Highest of 21 Years	Lowest	Date	Mean of Lowest of 21 Years	Range
	Deg	On	Deg	Deg	On	Deg	Deg.
January	52 5	19th	52 9	28 4	1st	23 9	24 1
February	53 8	19th	53 5	24 6	10th	26 3	29 2
March	57 8	30th	56 9	21 3	4th	25 7	36 5
April	58 2	19th	64 1	33 8	15th	31 3	24 4
May	77 0	23rd	70 3	42 6	3rd	35 1	34 4
June	76 2	27th	77 4	47 0	11th	41 9	29 2
July	75 5	7th	79 9	45 8	24th	46 4	29 7
August	77 5	1st	78 5	45 0	30th	45 3	32 5
September	71·4	11th	70 4	36 5	22nd	39 8	34 9
October	65 8	16th	63 1	36 4	11th	32 6	29 4
November	57 0	8th	56 4	27 2	27th	26 7	29 8
December	52 0	18th	53 0	28 0	29th	23 6	24 0
Means, or totals	63 7		64 7	34 6		33 4	29 1

Months.	Daily Mean, In Each Month: Of all Highest	Mean of 21 Years	Of all Lowest	Mean of 21 Years	Range: Mean	Range: Mean of 21 Years	Of Dry Bulb: Mean	Of Dry Bulb: Mean of 21 Years
	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg
January	43 8	42 9	35 9	34 3	7 9	8 6	40 9	39 2
February	42 9	44 2	33 5	35 3	9 4	8 9	37 8	39 7
March	45 4	46 3	34 3	35 2	11 1	11 1	39 6	40 3
April	49 3	52 6	39 1	39 5	10 2	13 1	43 4	44 7
May	61 5	58 3	48 5	43 8	13 0	14 5	54 1	49 6
June	68 3	65 2	52 2	50 1	16 1	15 1	59 4	55 8
July	65 9	68 3	52 6	53 8	13 3	14 5	58 8	60 1
August	64 4	67 2	53 0	53 1	11 4	14 1	57 8	58 9
September	60 3	61 8	50 2	49 5	10 2	12 3	55 2	54 5
October	51 2	53 7	42 2	43 2	9 0	10 6	46 8	48 1
November	49 0	47 3	41 3	38 4	7 7	8 9	44 7	42 8
December	43 3	42 8	35 2	34 4	8 1	8 4	40 2	39 2
Means, or totals	53 8	54 2	43 2	42 5	10 6	11 7	48 2	47 8

Months.	Adopted Mean Temperature, Of Air: Mean	Of Air: Mean of 21 Years	Of Evaporation: Mean	Of Evaporation: Mean of 21 Years	Dew Point: Mean	Dew Point: Mean of 21 Years	Vapour, Elastic Force: Mean	Elastic Force: Mean of 21 Years
	Deg	Deg	Deg	Deg	Deg	Deg	Ins	Ins
January	40 3	38 8	38 8	37 1	36 9	34 8	219	204
February	37 8	39 5	36 0	37 8	33 6	35 5	199	209
March	39 3	40 0	36 8	37 7	34 6	34 7	193	202
April	43 0	44 7	40 1	41 4	36 6	37 5	217	227
May	53 7	49 4	49 8	45 2	46 0	41 0	310	259
June	59 0	55 8	53 3	51 2	48 2	46 8	337	321
July	58 2	59 9	52 7	54 4	47 7	50 1	33	363
August	57 4	58 7	53 4	54 0	49 3	50 1	357	364
September	54 6	54 6	50 8	51 2	47 2	47 9	324	335
October	46 3	47 8	44 7	45 4	42 9	42 7	277	275
November	44 8	42 5	42 3	40 3	39 4	37 4	241	225
December	39 7	38 9	37 7	36 9	35 1	34 4	205	200
Means, or totals	47 8	47 5	44 7	44 4	41 4	41 1	267	265

Months.	Vapour, In a Cubic Foot of Air: Mean	Mean of 21 Years	Short of Saturation	Mean of 21 Years	Mean Weight of a Cubic Foot of Air.	Mean of 21 Years
	Grs	Grs	Grs	Grs	Grs	Grs
January	2 5	2 4	0 4	0 4	550	549
February	2 2	2 4	0 5	0 4	549	548
March	2 2	2 3	0 6	0 5	550	547
April	2 5	2 6	0 7	0 8	540	541
May	3 5	3 0	1 2	1 1	531	537
June	3 8	3 6	1 8	1 4	529	531
July	3 7	4 1	1 7	1 7	528	526
August	4 0	4 1	1 3	1 5	526	527
September	3 7	3 8	1 1	1 0	533	531
October	3 2	3 1	0 5	0 6	536	537
November	2 8	2 6	0 6	0 5	547	543
December	2 4	2 3	0 5	0 5	552	548
Means, or totals	3 0	3 0	0 9	0 9	539	539

Months.	Degree of Humidity (Complete Saturation = 100): Highest	Date	Mean of Highest of 21 Years	Lowest	Date	Mean of Lowest of 21 Years	Mean	Mean of 21 Years
	0—100	On	0 100	0 100	On	0 100	0 100	0 100
January	98	19th	97	64	29th	67	88	86
February	98	28th	97	48	10th	66	85	86
March	98	5th	96	56	29th	57	81	83
April	99	22nd	94	53	29th	53	79	77
May	98	24th	92	46	2nd	45	75	73
June	89	2nd	93	39	26th	48	68	72
July	86	26th	91	41	11th	48	69	70
August	93	21st	92	48	8th	51	75	74
September	93	19th	95	47	18th	55	76	78
October	99	15th	97	62	9th	62	89	83
November	94	13th	96	58	26th	63	82	83
December	97	24th	97	62	2nd	65	84	84
Means, or totals	95		95	51		57	79	79

Months	Bright Sunshine: Greatest Daily Duration.	Date	Total of Month.	Per cent. of Possible Duration	Temp. of Air in Sun's Rays: Highest	Date	Mean
	hr min	On	hr min		Deg	On	Deg
January	3 0	28th	15 15	6	77 0	30th	63 6
February	7 0	10th	69 40	22	92 5	19th	71 9
March	7 25	26th	66 55	18	94 8	30th	77 7
April	8 45	19th	60 5	14	99 0	19th	84 3
May	8 45	22nd	93 25	19	108 8	23rd	97 9
June	10 35	6th	183 45	36	115 9	23rd	102 3
July	12 15	8th	131 10	26	111 0	14th	101·1
August	9 10	18th	90 0	20	105 0	4th	98 2
September	8 40	29th	76 15	20	103 0	30th	88 2
October	4 40	9th	21 5	6	97 0	1st	74 1
November	4 20	3rd	27 5	11	86 8	11th	68 7
December	1 30	12th	3 15	1	63 0	17th	56 3
Means, or totals	7 13		827 45	18	96 1		82 0

Months	Wind, Direction: Relative Proportion of at 9 a.m.: N.	NE	E	SE	S	SW.	W	NW
	No	No	No	No	No	No	No	No
January	8	2	3	3	1	3	8	3
February	4	5	1	0	1	4	2	11
March	5	5	2	2	2	4	7	4
April	8	6	2	1	3	3	5	2
May	3	6	4	5	8	1	2	2
June	6	9	2	0	3	3	0	7
July	2	7	1	2	1	5	7	6
August	1	1	2	1	2	6	14	4
September	6	6	1	4	3	4	3	4
October	9	8	2	0	3	4	2	3
November	3	0	2	3	5	3	6	8
December	1	2	0	3	3	7	7	8
Means, or totals	56	56	22	24	35	47	63	62

Months	Wind, Velocity, At 9 a.m.: Mean	Highest	Date	During 24 hours: Mean	Highest	Date	Total Registered in Month
	Miles p'r hr	Miles p'r hr	On	Miles per d	Miles per d	On	Miles
January	6 5	16 6	24th	136	261	19th	4217
February	7 9	23 7	8th	189	362	9th	5280
March	5 6	15 0	26th	134	211	21st	4140
April	7 7	17 0	23rd	169	292	21st	5074
May	5 5	12 6	31st	125	240	31st	3878
June	6 0	11 9	1st	117	203	11th	3498
July	5 7	13 2	11th	125	225	7th	3877
August	6 4	14 8	28th	138	245	17th	4270
September	6 6	14 0	30th	108	264	27th	3245
October	5 9	24 9	7th	160	384	8th	4953
November	4 7	15 8	1st	111	206	1st	3326
December	4 6	25·8	18th	110	300	10th	3408
Means, or totals	6 0	17 1		135	268		49166

Months	Wind, Pressure: Mean of all Daily Highest	Mean of all Daily Highest of 6 Years	Highest	Direction.	Date	Mean of Highest of Month of 6 Years	Mean Amount of Cloud
	lb per sq ft	lb per sq ft	lb per sq ft		On	lb per sq ft	0 10
January	1 54	3 06	10 00	W S W	26th	12 54	9 1
February	2 60	3 00	12 00	W	9th	10 46	7 6
March	1 79	2 19	6 25	W	26th	10 17	7 6
April	1 57	2 43	4 00	W	2nd	8 21	8 0
May	0 75	2 34	2 50	E	8th	8 54	7 3
June	0 54	1 56	2 00	S	1st	7 04	4 7
July	0 50	1 62	2 50	W	26th	5 67	6 3
August	0 97	1 58	3 00	W	21st	6 38	7 3
September	0 98	1 91	4 00	S W	28th	6 54	7 9
October	1 13	2 33	4 50	S	7th	8 88	7 9
November	1 08	2 43	3 50	S W	3rd	9 83	7 5
December	0 86	2 77	3 50	S	18th	11 00	7 4
Means, or totals	1 53	2 27	4 81			8 77	7 4

Months	Rain: Number of Days it fell.	Amount Collected.	Greatest Daily Fall.	Date.	Mean of 20 Years	Mean of Seven Years ending with 1882, 65½ft. above surface of ground	Mean of 7 Yrs. endg. with 1882 at T'n Hall and Mid. Ry. Station on surface of ground	Gr'ter fall on surface at Town Hall & Mid Stn. than at 65½ft. above surface at Exch: Depth in Inches	Percentage of fall at Exch'ge
	No	Ins	Ins	On	Ins	Ins	Ins	Ins	Per cent
January	11	0 79	0 20	30th	2 59	2 209	2 474	0 265	11 2
February	16	1 47	0 27	14th	1 88	2 609	2 972	0 363	11 4
March	14	1 86	0 59	5th	2 22	2 776	3 260	0 484	11 7
April	22	2 96	0 47	7th	2 14	2 516	2 835	0 319	11 2
May	16	2 77	0 58	25th	1 79	2 103	2 277	0 174	10 8
June	3	0 14	0 12	1st	2 28	2 837	3 011	0 174	10 6
July	16	1 78	0 44	21st	2 97	3 401	3 641	0 240	10 7
August	22	3 35	0 47	20th	2 54	3 654	3 892	0 238	10 7
September	14	0 92	0 36	24th	2 71	2 894	3 229	0 335	11 2
October	20	3 83	0 56	8th	3 53	3 640	4 012	0 372	11 0
November	10	0 87	0 20	15th	2 89	3 421	3 828	0 407	11 2
December	11	1 40	0 42	21st	2 64	3 681	4 170	0 489	11 3
Means, or totals	175	22 14	0 39		30 18	35 741	39 601	3 860	11 08

METEOROLOGY OF BRADFORD FOR 1889.

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, Humidity, Bright Sunshine, Wind Pressure, and Rainfall.

Year	Pressure: Highest: Reading of Barom during Year	Pressure: Highest: Date	Pressure: Lowest: Reading of Barom during Year	Pressure: Lowest: Date	Temperature: In Shade: Highest: R'ding of Maximum Thermom during Yr	Temperature: In Shade: Highest: Date	Temperature: In Shade: Lowest: R'ding of Minimum Thermom during Yr	Temperature: In Shade: Lowest: Date	Temperature: Last and First Frost of Seasons: Date of Last Frost	Temperature: Last and First Frost of Seasons: Date of First Frost	Temperature: In Sun's Rays: Highest: Reading of Solar Thermom. during Yr.	Temperature: In Sun's Rays: Highest: Date	Humidity (Complete Saturation = 100.): Highest: Degree of Humidity during Yr	Humidity: Highest: Date	Humidity: Lowest: Degree of Humidity during Yr	Humidity: Lowest: Date	Bright Sunshine: Greatest Daily Duration	Bright Sunshine: Date	Bright Sunshine: Total of Year	Bright Sunshine: Per cent of Possible Duration	Wind Pressure: Highest	Wind Pressure: Date	Rain: Total for Year	Rain: Mean Y'rly Rainfall at Town Hall and Mid Rly Stn on surface of g'nd	Rain: Gr'tr fall on srfce at T'n H'll & Mid Stn than at 65½ ft ab've surf at Exc: Depth in Inches	Rain: Gr'tr fall on srfce at T'n H'll & Mid Stn than at 65½ ft ab've surf at Exc: Percentage of fall at Exch'ge	Rain: Greatest Daily Fall during Yr	Rain: Date	Snow: Last and First Snow of Seasons: Date of Last Snow	Snow: Last and First Snow of Seasons: Date of First Snow
	Ins		Ins		Deg		Deg				Deg		0 -100		0 - 100		hr min		hr min		lb per sq ft		Ins	Ins	Ins	Per cent	Ins			
1869	30 290	Dec 6	28 500	Feb. 1	85 2	Aug 30	19 8	Dec 28	Mar 27	Oct 20	127 7	Aug 30	99	Feb 8	42	Sep 24												....	April 3	Oct 19
1870	30 284	Jan 19	28 308	Jan 8	85 0	July 26	16 6	Dec 23	Mar 30	Nov 9	127 5	July 25	98	Jan 29	40	July 14							24 120				0 820	June 18	Mar 24	Nov 15
1871	30 152	Mar 28	28 308	Jan 16	84 0	Aug 12	6 7	Jan 1	April 11	Nov 13	128 7	July 17	98	July 7	43	Nov 2							21 640				0 985	June 16	Mar 15	Nov 16
1872	30 156	April 6	28 070	Jan 24	86 4	July 23	24 8	Mar 27	Mar 27	Nov 19	124 8	Aug 19	100	Mar 22	45	Sep 23							42 060				2 490	June 19	May 11	Nov 13
1873	30 338	Feb 18	28 022	Jan 20	88 8	July 23	19 2	Feb 24	Mar 14	Nov 5	124 5	July 23	100	Dec 11	41	Mar 26							21 440				1 260	Aug 4	April 25	Jan 3, '74
1874	30 476	Mar 6	28 276	Dec 11	80 9	July 20	15 0	Dec 31	Mar 12	Nov 11	125 8	July 20	100	Feb 6	42	May 18							23 560				0 740	Dec 7	May 9	Nov 26
1875	**30 305**	**July 7**	**28 484**	**Nov. 10**	**80·0**	**Aug. 17**	**13·0**	**Jan. 1**	**Mar 22**	**Nov. 26**	**122·0**	**July 6**	**100**	**Jan. 23**	**43**	**July 6**	......	......	......	......	......	......	**30 280**	......	......	......	**1·700**	**Nov. 15**	**Mar. 12**	**Nov. 9**
1876	30 300	Jan 15	28 070	Dec 4	87 6	July 17	23 0	Jan 9	April 15	Nov 9	125 6	July 16	99	Oct 4	46	May 5							35 270	39 788	4 518	11 28	1 810	Oct 9	April 12	Nov 8
1877	30 358	Oct 6	28 300	Nov 29	80 0	June 19	20 0	Mar 1	May 4	Oct 18	116 4	June 19	100	Oct 29	35	May 23							40 650	45 499	4 849	11 19	1 420	July 16	May 19	Oct 15
1878	30 320	Mar 16	28 630	April 1	89 6	July 19	13 9	Dec 26	April 6	Nov 9	118 2	July 22	99	Jan 13	63	Aug 9							35 434	39 010	3 576	11 01	1 220	Aug 14	April 1	Nov 8
1879	30 352	Dec 13	28 500	Feb 10	74 4	July 30	13 2	Dec 7	May 10	Nov 14	101 2	Aug 13	100	Oct 7	51	Dec 12							28 017	30 298	2 281	10 82	1 020	June 8	May 7	Nov 20
1880	30 332	Jan 7	28 154	Nov 16	81 3	Sep 5	20 8	Jan 20	Feb 23	Oct 20	112 0	Aug 13	99	Dec 15	50	May 30							35 690	39 616	3 926	11 10	1 710	Oct 27	Mar 2	Oct 27
1881	30 382	May 10	28 250	Oct 14	83 3	July 6	12 0	Jan 26	April 21	Oct 17	116 5	June 1	98	Oct 14	38	May 31							35 434	39 892	4 458	11 26	1 435	Oct 13	April 20	Oct 29
1882	30 544	Jan 18	28 452	Mar 1	77 4	Aug 12	18 6	Dec 11	April 16	Nov 12	108 0	Aug 9	99	Nov 5	36	May 18							39 683	43 103	3 420	10 86	1 608	Dec. 6	Mar 21	Nov 19
1883	30 500	April 9	28 452	Sep 2	76 2	July 3	19 8	Mar 10	Mar 29	Nov 12	107 6	May 17	99	Dec 26	30	April 9							34 396				1 338	Sep. 26	Mar 24	Nov 10
1884	**30·354**	**Oct. 5**	**28 376**	**Jan. 27**	**84·4**	**Aug 12**	**26·5**	**Nov. 30**	**April 24**	**Nov. 24**	**107 8**	**Aug 9**	**98**	**Jan. 23**	**30**	**May 22**	......	......	......	......	**24 00**	**Jan. 24**	**27·667**	......	......	......	**1 170**	**Jan. 23**	**Feb. 28**	**Nov. 23**
1885	30 273	Mar 14	28 400	Jan 11	82 2	July 27	22 1	Dec 11	April 5	Nov 16	113 6	July 27	100	Jan 23	32	June 4					15 25	Dec 4	25 699				1 208	Sep 3	May 7	Dec 9
1886	30 355	Nov 24	27 452	Dec 8	79 5	July 3	17 4	Mar 7	April 30	Dec 2	108 8	July 5	99	Jan 12	32	May 4	11 45	July 6	851 48	19	18 00	Dec 9	35 993				2 130	July 26	May 12	Nov 6
1887	30 412	Feb. 8	28 328	Nov 3	82 8	July 9	21 1	Jan 17	April 17	Oct 12	107 6	July 9	100	April 21	35	July 9	12 40	July 3	1120 58	25	15 00	Feb 4	18 665				0 610	Oct 9	May 21	Oct 14
1888	30 333	Jan 10	28 410	Mar 28	80 4	June 27	19 2	Feb 14	April 8	Oct 2	110 0	Sep 15	99	Mar 15	39	June 11	13 40	May 24	884 20	20	13 00	May 4	25 646				1 050	Nov 3	April 8	Oct 1
1889	30 358	Dec 5	28 460	Mar. 20	77 5	Aug 1	21·3	Mar 4	Mar 22	Nov 27	115 2	June 23	99	April 22	39	June 26	12 15	July 8	827 45	18	12·00	Feb 9	22 141				0 590	Mar 9	Mar 21	Nov 25
Means	30 342		28 305		82 2		18 3				116 6		99		40		12 35		921 15	20	16 21		30 174	39 603	3 800	11 08	1 323			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8.40 p.m. the mercury of the Exchange barometer had fallen to 27·456 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

Bright sunshine is recorded in hours and minutes by glass sphere on cards, known as Campbell's recorder, fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·86 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the twenty years ending with 1889 is 30·174 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 33 517 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

1922 [illegible]

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ON THE CHANGES OF THE LOWER CARBONIFEROUS ROCKS IN YORKSHIRE FROM SOUTH TO NORTH.

BY J. R. DAKYNS,

OF H.M. GEOLOGICAL SURVEY.

In order to understand the geology of the country north of the Aire, I will first give a short sketch of the chief features presented by the Millstone Grit and Lower Carboniferous measures, as we follow the beds from Derbyshire to Wensleydale.

In Derbyshire the Millstone Grit, as hitherto defined, consists in descending order of four or five well-marked grits, separated by shales, viz. the so-called first or topmost grit, named also Rough rock from its coarse character ; the second grit, generally a flagstone ; the bold, well-jointed rock of Hathersage Edge and Stanedge, or the third grit ; and lastly, the fourth or Kinderscout grit, which sometimes consists of two beds.

Below the Kinderscout grit comes a thick and variable series of sandstones and sandy shales, the "shale grit" of Farey, which has been generally called the Yoredale or Upper Yoredale grit ; and then come shales in which sometimes occur siliceous sandstones, known as Yoredale Sandstones, or Lower Yoredale Grit ; then come calcareous shales; and finally the Carboniferous Limestone of unknown thickness, the upper part of which is thin-bedded and cherty, the lower massive and free from chert.

Going northwards this type undergoes great changes; the second grit is merely a basement bed to the Rough Rock, from which it cannot always be separated; the third grit loses its massive character in many places; and other beds of sandstone show themselves amid the shales overlying the Kinderscout grit.

In the valley of the Colne there are four sandstones between the Rough or Sand Rock and the recognised Kinderscout grit; the same is the case in the valley of the Yorkshire Calder; but in the basin of the Aire the series consists in descending order of the following beds: First, the Rough Rock, which maintains throughout its usual character till it is lost to sight beneath the Permians; seccondly, a very variable basement bed to the last, consisting generally of flagstones. Below this comes a series of variable sandstones and shales, sometimes containing as many as fifteen or sixteen distinct beds of sandstone between the Rough Rock and the regular Kinderscout grit. This set of beds may, however, be conveniently divided into two by means of the massive grit of Hallan Hill and Earl Crag, which is continuous with the third grit of Lancashire. It is this rock which, according to the mapping of Mr. Lucas, forms the well-known Brimham Rocks, near Pateley Brig.

Owing to the number of sandstones that have now come in, it is somewhat uncertain what ought to be taken as the top of the Kinderscout grit; but there is no doubt whatever about the main mass of the bed, for it retains throughout the country its character of a very coarse and massive grit, forming crags and stacks of rock. It is underlaid by a thick but variable series of sandstones with shale partings. As there is ofttimes no definite line of separation between these beds and the Kinderscout grit, we now classify them with the millstone grit, and call them Pendle grits, because they form the chief features of that conspicuous hill. Below them lie the Black Bolland shales, at the base of which comes sometimes what Mr. Tiddeman has called the "Lower Yoredale Grit." In lithological character the beds of this grit answer very well to certain hard silicious sandstones of the Yoredale series, known to miners as Dirt Pot grits. In the neighbourhood of Skipton the Kinderscout and Pendle grits are underlaid by a great thickness of shales containing two well-marked limestones, viz., those of Eastby and of Embsay. Below the shales comes the thick limestone (800 feet seen) of Haw Bank. It is a dark thin-bedded limestone, precisely similar in character to the Thornton limestone, to which it is probably equivalent. It is extensively quarried for road metal in the Haw Bank near Skipton. The strike of the beds south of the Aire is generally N.E. and S.W., the dip increasing westward; but about the latitude of Skipton the beds bend round so as to strike nearly east and west, with a dip of 20° to the south on Skipton Moor. An anticlinal ranges along Skibeden from Skipton to Bolton Abbey, with a steady dip to the north, and many a fold on the south. Thus the mountain limestone of Haw Bank has been brought up between two ranges of millstone grit hills, viz., Skipton Moor on the south and Embsay Moor on the north. The beds are much faulted and contorted, particularly along the south side of Skibeden. Good instances of contortion are to be seen at Draughton and Wheelam Rock Quarries, and at the Hambleton Rock Quarry; and a fine section of contorted beds is to be seen in Haltongill.

The Kinderscout grit of Skipton and Draughton Moors striking east descends to the River Wharf, north of Addingham. Its high southerly dip carries it up the slope of Langbar Moor, its base running just below Beamsley Beacon. It then, under the influence of a branch of the Skipton anticlinal, plunges down northward to the Kex Beck, where the beds bend up again and rise northward to Hazlewood Moor and Bolton Park. Here, on the strike of the Skipton anticlinal, the beds bend over northward, and recross the Wharfe below Laund House. South of this, as far as Bolton Abbey, limestones and shales are seen along the river.

The Pendle grits run along the slope of Skipton Moor to Fairfield Hall; and east of the Wharfe are found about Beamsley and Storriths. They have not been everywhere identified on the north side of Skibeden. The general run of the beds on this side is, however, tolerably plain. A set of bold crags marks the escarpment of this Kinderscout grit along Halton and Embsay Moors, Rylstone, Burnsall, and Thorpe Fells. Beneath the western escarpment of the Kinderscout grit, the Pendle grit forms at intervals promontories on the Fell side. It has not been traced further than the northern extremity of Burnsall Fell. The Kinderscout grit lies in the shape of a synclinal trough dipping eastward; and it thus occupies with its various members the whole extent of Burnsall Fell, Barden, and Embsay Moors. The rock is well seen along the Wharfe, particularly at the celebrated Strid in Bolton Woods. On the east of the Wharfe these grits rise up in a sort of broken dome, with a quaquaversal dip to form the summit of Barden Fell, marked by the bold crags of Simon Seat. Near these crags, at the very summit of the Fell, more than 1,450 feet above the sea, some pot holes, one of which from its size is called "the great shak," mark the presence of limestone beneath the surface. The grits may be seen in Howgill and in Fell Plantation, dipping steeply to the N.W. into the valley; but along Skyreholme Beck they turn up and dip steeply to the S.E. From Appletreewick the grits strike north-eastward, underlaid by a mass of shale, from beneath which massive beds of white scar-forming limestone rise regularly with a similar strike, as far as High Crag. Here the beds abut against the Craven Fault. The details of the limestone country immediately south of the fault are complicated, but the general structure is simple enough. A broad band of limestone stretches across the Wharfe from High Crag to Cracoe in the form of an anticlinal ridge, which between Cracoe and the river runs from S.W. to N.E. Along its N.W. flank we find the limestone dipping N.W., at angles of 40° beneath beds of shale having a similar dip. On the S.E. side the dip is to the S.E.; but on this side the boundary seems to be partly a faulted one, as the lower grits on the flanks of Thorpe Fell are striking nearly at the limestone; but I shall not insist upon this, as Mr. Tiddeman has recently made some discoveries which will throw great light on the structure of the country, and it may turn out that the above-mentioned appearance of a fault is deceptive. I shall therefore merely give a brief statement of observed facts, without drawing any inference from them. The limestone is everywhere precisely similar in external appearance to the massive thick-bedded white scar-forming limestone, which forms the main portion of the carboniferous limestone of the Yorkshire Dales, and is very fossiliferous. It forms five striking hills, more or less conical, that stand out abruptly from the general level of the ground lying at the foot of the Gritstone Fell. The names of these hills are Skelterton, Butter Haw, Stebden Hill, Elbolton, and Keal Hill. On Skelterton the beds have an easterly dip. Butter Haw shows an anticlinal structure. On the north side of Stebden the beds dip N.W. at 40°, but no good dip could be got on any other part of the hill ; on the south side the limestone is disturbed, and here too the basement beds of the millstone grit strike at the limestone. As to Elbolton I found it quite impossible to make out how the beds are running ; at the foot of the hill I got dips which would imply that the hill is a dome with a quaquaversal dip : but on the hill itself I could get no dips at all ; so being baffled outside I tried the inside ; for the hill is traversed by veins and pipes of galina, and entrance into the very heart of the rock is to be had by the mine adits, but I met with no better success inside than out ; everywhere alike the limestone seems to be an amorphous mass. The same may be said of Keal Hill, where also I could get no dips.

On the east side of the Wharfe a very good section of the limestone is to be seen in Skyreholme Gill. The beds flatten as we go up the gill, and at length turn over and dip north, so that we come to the top of the limestone on the north side of the anticlinal. On this side there is a bed of encrinital and cherty limestone between the main mass of limestone and the millstone grit of Fancarl Crag, which is an outlier, bounded on the north by the Craven Fault. I will now give the evidence for the position of this fault. On the west its line is plainly marked from Bordley to Threshfield by the opposition of the limestone of Malham Moor and Skirethorns Wood on the north, to grits and shales on the south of the hollow running from Bordley to Skirethorns. It was for a long time a matter of uncertainty where the fault crosses the Wharfe, but a heavy flood one winter exposed a bed of coarse grit in the river just below the Linton Stepping Stones. This gave a point on the fault. Between the Wharfe and the River Dibb the position of the limestone top is very uncertain, as the beds are quite hidden by drift ; but the fault must pass north of the grit outlier on Ratlock Hill, near Thruskeld. The strong spring, whence the place takes its name, is probably on the fault. In the River Dibb the position of the fault is fixed approximately just above Dowscar Nook by the fact of there being grit in place with limestone on either side. A mile further east the position is fixed exactly by the abrupt termination of the grit of Fancarl Crag against limestone on the north; and similarly a mile and a half further east by the end of the millstone grit escarpment at High Crag.

On the north side of the Craven Fault we have, east of the River Dibb, massive white limestone, dipping north at 19° under a thin band of shale, above which comes the millstone grit of Grimwith Fell. Greenhow Hill is the dome-shaped end of this band of limestone, and is an anticlinal broken by the Craven Fault.

Between the River Dibb and Grassington the ground is very obscure; but the millstone grit seems to be separated from the limestone by a great thickness of shales with but poor limestone bands. At Grassington, however, the limestones swell out, so that with the exception of the Dirt Pot grits there is solid limestone from the millstone grit of Grassington Moor down to the River Wharfe.

Northwards this thick limestone splits up, and finally takes on the Yoredale type. At Kettlewell upwards of 775 feet of carboniferous limestone are seen. This mass consists of solid limestone, forming scars, but without any interbeds of plate or sandstone. The overlying Dirt Pot grit can be distinctly traced from Grassington to Kettlewell by reason of its throwing out the water percolating the limestone above it.

At New Rake vein the section is as below:—

Bearing Grit.
Limestone encrinital.
Thin Sandstone or Shale Band.
Limestone.
Dirt Pot Grit.
Carboniferous Limestone.

Northwards the uppermost limestone runs away from the millstone grit, the intermediate space being occupied by plate with a thin limestone.

The limestone above the Dirt Pot grit, which is here the lowest of the Yoredale Beds, is that which we call the Simonstone, and which Phillip's called the Simonside Limestone. It is about 16 yards thick near Kettlewell. It is overlaid by plate, and the plate by a thick limestone, Phillips' Middle Limestone, which is about 32 yards thick near Kettlewell. Over the Middle Limestone there comes in the Providence mine a series of alternating beds of plate and limestone, upwards of 36 yards thick. There is no recognisable bed answering to the Underset or Main Limestone ; but these important beds soon make their appearance as we go north.

The Main or Coverhead Limestone begins to put in a respectable appearance at Caseker, and soon swells out to an important rock, forming a plateau at the head of Coverdale with a fine escarpment towards Wharfedale. It is immediately overlaid by the Bearing grit ; but northwards a set of cherty beds comes in between the pure limestone and the grit ; at first, as at Coverhead, this is merely a thin chert top to the limestone, but this gradually develops into a series of cherty beds, sandstones, and shales, known as the Swaledale Black and Red Beds, and further north as the Coal Sills.

East of the Wharfe the Millstone Grit Series generally consists of the following members :—

Shale.
Sandstone.
Shale.
Sandstone.
Shale.
The Brimham Grits.
Shale.
The Shell Beds.
Shale.
The Upper Grit of Follifoot Ridge.
Shale.
The Lower Grit of Follifoot Ridge.
Shale.
A Thin Limestone.
Kinderscout Grit in several beds.
Pendle Grits, thin away north, or so coalesce with the beds above as to be inseparable from them.

The Brimham rock consists generally of coarse grit, with sometimes a flaggy base ; the shell beds are cherty sandstones full of shells. This is a very valuable set of beds, as from its peculiar character it can be readily identified, and thus affords a good horizon.

The Lower Follifoot grit forms Henstone Band and the top of Meugher.

In placing the top of the Kinderscout grit at the horizon of the little limestone next below the Lower Follifoot grit, I mean that it cannot be lower, though it may be higher, than that horizon. The Brimham grit is supposed to be the third grit of Lancashire ; and, according to this view, the shell beds and Follifoot grits come between the third grit and the Kinderscout grit.

In Upper Wharfedale the Kinderscout grit consists of the following members :—

The Red Scar Grit.
Measures.
Sandstone.
Measures.
Sandstone, of Priest Tarn, probably equals grit of Pinlow Pike.
Measures.
Coal 0 to 6 inches.
Top Grit of Grassington Moor.
Shale, with a coal, 6 to 10 inches.
Bearing Grit.

The Bearing Grit is so-called because the lead veins are very rich in this bed.

The Red Scar Grit is a coarse felspathic grit of a red tinge, which is apt to form such conspicuous red scars that it can be recognised miles away. It often consists of two members parted by a shale band containing a coal seam. It generally has on or near its top a thin bed of peculiar limestone, which has the appearance of a tesselated pavement owing to its close jointing.

It is also noteworthy that bands of calcareous sandstone occur in Gatcup, near the base of the Red Scar Grit. Similar bands have been found by Mr. J. E. Goodchild, generally underlying the rock which, in Wensleydale, we identified on purely strategraphical grounds as the equivalent of the Red Scar Grit.

This grit is the middle grit of Phillip's mentioned on page 65 of his Geology of the Mountain Limestone district, where he is quite right in saying that "it corresponds in position with the top grit of Penhill."

In Coverdale the upper part of the grit is a white siliceous rock with rootlets, like ganister. Similar ganister-like rocks with Stigmaria also occur higher in the series. The frequent occurrence of ganister above the Red Scar Grit is important, and it is worthy of note that even as far south as Derbyshire ganister beds are apt to occur about this horizon, *i.e.*, over the Kinderscout grit. In Coverdale these ganister beds begin to be very numerous and characteristic of the beds.

The lowest millstone grit is at its outcrop throughout Wharfedale a coarse and massive grit; but Mr. Eddy tells me that in following the lead veins eastward in the Bearing grit the rock was found to degenerate into a mass of sandy shales and flags. At the head of Coverdale these lowest grits are in full force; but they rapidly deteriorate down dale into a mass of sandy shales and thin poor sandstones. This change sets in immediately east of Crab Gill. A similar change in character takes place as one follows the grits down Walden.

I have given above a brief sketch of the chief changes which the Lower Carboniferous Rocks of Yorkshire undergo from south to north. These may be summed up as follows:—

1. The simple fourfold division of the millstone grit prevalent in Derbyshire ceases to be applicable northward, owing to the setting in of several fresh beds of sandstone.
2. The Yoredale type of beds can hardly be said to exist south of Kettlewell. From Grassington northwards the Carboniferous Limestone becomes split up by beds of sandstone and shale; and north of Kettlewell important rocks, to wit, the Underset and Main Limestones set in, so that finally we have in Yoredale the well-known type of beds that goes by that name.
3. In the southern part of its course the Main Limestone is imme-

diately overlaid by the Millstone Grit ; this begins at Lowerhead merely as a thin cherty top to the limestone ; but the chert gradually develops into a series of cherty beds, shales, and sandstones, known as the Black and Red Beds in Swaledale. Still further north the cherty beds change into a set of water-bearing sandstones, grits, and shales, known as the Coal Sills, overlaid by a thin but persistent bed of limestone, known as the Little Limestone.

4. Owing to the deterioration of the lowest Millstone Grit in Walden and Coverdale and on the flank of Penhill, it is somewhat uncertain what line should be taken further north as the Millstone Grit base, so as to keep to the same horizon. But in my opinion the best line (at least the most certain line) to take is the top of the cherty series and its equivalent, the Little Limestone. I am aware that lithologically this would not be a good line in some parts of Northumberland ; but then we should at all events keep to one and the same horizon.
5. It is important to notice that the silicious grits and ganister-like beds that occur in the Millstone Grit series above the Kinderscout grits become more pronounced northwards, so that at length they become regular ganister measures, similar to those that occur in the lower part of the Coal Measures.

NOTES ON THE POLYZOA AND MICROZOA OF THE RED CHALK OF YORKSHIRE AND NORFOLK.

BY GEORGE ROBERT VINE.

I. INTRODUCTORY.

From the time when John Phillips, F.G.S. (1829), published his "Illustrations of the Geology of Yorkshire," up to the present, the origin and probable horizon of the Red Chalk, have been fairly discussed by authors. It is only within the last thirty years, however, that the stratum has been worked out with any degree of skill, or that any attempt has been made to co-relate the Red Chalk beds, by means of their fossil contents, of Norfolk, Lincolnshire and Yorkshire. Then again, the differences of opinion which have been expressed by authors who have studied the palæontological evidence, have helped to advance the importance and relative value of the fossil contents of this very peculiar band. It is not my intention, therefore, to comment on opinions raised by men who are far more competent to deal with the subject than I am, but a brief *résumé* of what has been done will serve as a necessary preface to what will follow.

In 1829, as regards Yorkshire, John Phillips gave a list of five fossils only, under the head line "Fossils of the Red Chalk," two of which were figured.* As regards Hunstanton, Professor Sedgwick in 1826† remarked in a foot note "that the red beds of Hunstanton Cliff . . . . . contain the peculiar fossils of the *galt* in great abundance."

In 1833, Mr. S. Woodward in "An outline of the Geology of Norfolk,"‡ gave a list of fossils of the Hunstanton Beds; and Mr. C. B. Rose (1835), in a series of papers in the Philosophical Magazine, followed with remarks on the probable horizon of the Red Beds. As the history and literature of this side of the subject have been given so admirably by Professor Seeley up to 1861,|| and up to

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* Geol. Yorkshire, p. 120, pl. 1, figs. 18-19.

† Annals of Philosophy, Ser. 2, vol. xi., p. 378.

‡ 8vo, pp. 29-54.

|| Ann. Mag. Nat. Hist. Ser. ii., vol. vii., pp. 233-244,

1882 by Mr. W. Whitaker, F.G.S., of the Geological Survey of England, (*) it will perhaps be as well to refer the student to these papers for special details, as I could only feebly repeat here remarks and expressions of opinion which these respected authors have said so well in the papers referred to.

In the year 1859† the Rev. T. Wiltshire read a paper before the Geologists' Association on the Red Chalk of England, and to him belongs the credit of bringing forward the subject in a systematic way. He describes the Red Chalk through Yorkshire, Lincolnshire, and Norfolk, "notices that whilst many of the fossils at Hunstanton are Gault species, others are Lower Chalk species, and concludes that probably it is better to regard it as an intermediate formation between the Lower Chalk and the Lower Greensand, which comes into being when the Gault and Upper Greensand have almost thinned out." In the list of fossils (pp. 275, 277) Mr. Wiltshire catalogues a very fine series derived from Speeton, Hunstanton, and Muswell Hill. A few species of *Foraminifera*, *Entomostraca*, and *Polyzoa* are given by the author, altogether 47 species are catalogued, which, aided by the clear and precise description of the Red Rocks in the text of the address, added considerably to our knowledge of the palæontology of these rocks up to that date. The "microzoa" were as follows :—

Foraminifera:	Cristellaria rotulata, Lamk. Collection of Prof. T. R. Jones.
Entomostraca:	Cytherella ovata, Rœmer. Collection of Prof. T. R. Jones.
Polyzoa:	Idmonea dilatata, d'Orb. Collection of Mr. Bean.
,,	Diastopora ramosa (Dixon) Lonsd. Collected by Mr. Wiltshire.
,,	Ceriopora spongites, Goldfuss. Collected by Mr. Wiltshire.

The other fossils were in different collections, named by Mr.

(*) Proc. Norwich Geol. Soc,, vol. i., pt. xvii., 1883.

† *Geologist* vol. ii., pp. 261-278. This paper was printed separately, pp. ii., 18, with 4 plates of Fossils, but I have not been successful in getting a copy; so I quote from the *Geologist*.

Wiltshire, but the whole of the examples catalogued were examined and compared with like fossils in other public and private collections.

Two years after Mr. Wiltshire's paper was published Professor H. G. Seeley gave the first of a series of four papers which were wholly devoted to the "Red Limestone of Hunstanton."* In it "he reviews the literature of the subject, and notices the weak points of the various papers reviewed . . . . and concludes that the Red rock is Upper Greensand, because it is linked to the Chalk, and yet differs from it in fossils." In an analytical table of fossils of the red bed Professor Seeley shows affinities with, and differences from, the fossils of the Upper and Lower Cretaceous Rocks.

In 1864 Professor Seeley wrote another paper† on the Hunstanton Red Rock, which was devoted rather more to the Geological than to the Palæontological aspect of the same. Unless this paper is very carefully gone through, and the chalky material of the Hunstanton Beds studied by its aid, it is impossible to understand the differences between the red beds of Norfolk and Yorkshire. In the one we have hard chalk containing pebbles and minute grains, in the other much softer chalk, with scarcely any perceptable mixture other than the colouring matter present. The *Foraminifera*, too, of the Yorkshire Red Chalk, are much larger than the Hunstanton species. Judging from these differences one can easily imagine that the finer *débris* in solution floated farther north in the Red Chalk Sea, whereas the coarser material was deposited farther south.

The Red Rock, says Professor Seeley, "is divisible into three parts, III. Lower, II. Middle, and I. Upper. "In the lower of these beds . . . as in the others, the little brown and black shining pebbles . . . in the Carstone pass up. . . . The lowest layer is sandy, and not more clearly separated from the Carstone below than from the concretionary layer above. The top layer is like the sponge bed above‡ in structure . . . but often there is a thin soapy seam of deep red matter. . . . parting them ; and at intervals this enlarges into nest-like burrows, which . . . extend for several inches up into the sponge rock, without affecting the level top of the Red Rock. These spaces are filled with soft red matter, or with sand."

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* Quart. Journ. Geol. Soc, vol. xx., pp. 327-332.

† Ann. Mag. Nat. Hist., Ser. iii., vol. vii., pp. 233-244, 1861.

‡ These beds contain a very peculiar fossil in abundance called *Spongia paradoxica*, of authors.

By far the most important of Professor Seeley's papers from a palæontological standpoint is the one published in the Annals in 1864, on the Fossils of the Hunstanton Red Rock.* As in a previous paper Prof. Seeley remarks that the rock at Hunstanton may be divided into three parts, or three well-marked layers of nearly equal thickness, and these may be numbered in descending order, 1, 2 and 3. Then follows a list of about eighty-seven named species, and nearly twenty more fossils indicated by generic names only, or varieties. The whole of these fossils were collected by the author, and are now deposited in the Woodwardian Museum at Cambridge. In this list Prof. Seeley introduces a new feature of great interest to the palæontologist, by locating the fossils, as far as he was able to do so, in the several layers. Certain species are peculiar to the lowest (No. 3). *Belemnites attenuatus* and *minimus; Plicatula sigillina: Terebratula capillata, biplicata,* and *Dutempliana,* range through the whole of the layers; a still less number of species range through layers 2 and 3, and by far the greater number are found in the top bed only. It was unfortunate for me that when writing my "Monograph of the Polyzoa of the Red Chalk of Hunstanton,"† this paper was overlooked, especially so, as an acquaintance with it would have prevented the error on p. 456, of the Monagraph, and have saved me from after annoyance. In Prof. Seeley's list I find the following Polyzoa mentioned: the new species being described in the last of the series of Hunstanton papers in 1866.‡

1. Diastopora (*Berenicea*) polystoma, Rœm.
2. ,, (,,) contracta, Seeley.
3. ,, (,,) clementina, d'Orb.
4. Proboscina dilatata, d'Orb.
5. Cellulipora sulcata, Seeley. (*Diastopora* of this paper.)
6. Reptomulticava n-sp. (R. favus, Seeley of this paper.)
7. Reptotubigera serpens, d'Orb.

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* **Ann. Mag. Nat. Hist., Ser. 3, vol. xiv.**

† **Quart. Jour. Geol. Soc., vol. xlvi., pp. 454-486 (1890).**

‡ **Ann. Mag. Nat. Hist., Ser. 3, vol. xvii., pp. 173-183,**

In 1869, seemingly in answer to Prof. Seeley, who characterised his last paper as one on the fossils (new and rare) of the "Upper Greensand of Hunstanton," Mr. Wiltshire's second paper was published in the Journal of the Geological Society.* In this paper will be found a rather full list of fossils, and a drawing of the cliff section. The Red Chalk beds or bands are marked A B and C, and Mr. Wiltshire assigns to each of these layers the fossils which are either peculiar or common. Four species of Polyzoa are named and located thus :

1. Diastopora (Berencia) regularis, d'Orb.	Band B.
2. Proboscina dilatata, d'Orb. (rare)	,, C.
3. Reptomulticava mamilla, Rss.	Bands B. & C.
4. Stomatopora longiscata, d'Orb. (rare)	,, C.

The last paper in which, so far as I am aware, Polyzoa are mentioned, is "On things in General and the Red Chalk of Norfolk in Particular "† by the then president, Mr. W. Whitaker, of the Norwich Geological Society.

The address is divided as follows :—

a. Notes on Norfolk Geology, pp. 207, 212.

b. The Red Chalk of Norfolk.

1. Introductory, p. 212.
2. History of the subject (Bibliography), 213, 222.
3. Critical Remarks, pp. 222, 226.

4-5. Personal experience and conclusion, 226, 234.

6. List of fossils, compiled, I believe, by A. J. Jukes Browne from the Red Chalk of Hunstanton, showing their range, &c., in the Cretaceous series. This list might have been conveniently reproduced, but the student is advised to compare the lists of Whitaker, Wiltshire and Seeley, particularly when the later investigations of Messrs. A. J. Jukes Browne and W. Hill come under his consideration.

Polyzoa of the Red Chalk of Hunstanton (Whitaker, p. 234) :

1. Diastopora (*Berenicea*) contracta, Seeley.
2. ,, (,,) regularis, d'Orb.

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* Quart. Journ. Geol. Soc., vol. xxv., pp. 185-192.

† Proc. Norwich Geol. Soc., vol. i., pt. vii., 1883, pp. 207-236.

3. Cellulipora sulcata, Seeley.
4. Proboscina dilatata, d'Orb.
5. Reptomulticava mamilla, Reuss.
6. Stomatopora longiscata, d'Orb.

Besides the above, Mr. Whitaker catalogues in the same paper two species of *Foranimifera*, but no *Entomostraca* :

1. Cristellaria rotulata, Lamx.
2. Globigerina cretacea, d'Orb.

A few expressions of opinion from competent authorities as to the probable horizon of the Red Chalk, may be given before closing this part of my paper.

In 1878, the Rev. E. Maule Cole read a paper before the Yorkshire Geological and Polytechnic Society, on "the Red Chalk,"* in which rather full details are given of the various sections of the Red and Grey Chalk found in Yorkshire. These two terms "Red" and "Grey," Mr. Cole uses "indiscriminately, because I believe" he says "that many beds which present no traces of red colour belong to this formation. At the north end of Burdale tunnel there is a deposit of upwards of 20 feet, similar in texture to the Red Chalk of Speeton, with no trace of flint, of a greyish colour, and showing when broken, rich chocolate markings resembling the black spots indicating Manganese. It contains Terebralulæ, but of a much smaller kind than those found so abundantly at Speeton."

A similar formation, or rather the same, appears at another point nearer North Grimston, exposed for a length of several hundred yards on the same east side of the valley. On the west side it also appears at the base of the chalk, opposite Wharram Station (where there are springs at an elevation of 475 feet), with the same peculiar markings. It occurs at Dalglely and Nova. It is not White Chalk, it cannot be called Chalk Marl exactly, though at Nova and other places it is friable and clayish ; but it must be the equivalent of the formations known in the south under the terms Chalk Marl, Upper Greensand, and Gault," pp. 5.

In a very elaborate paper† on the lower part of the Upper

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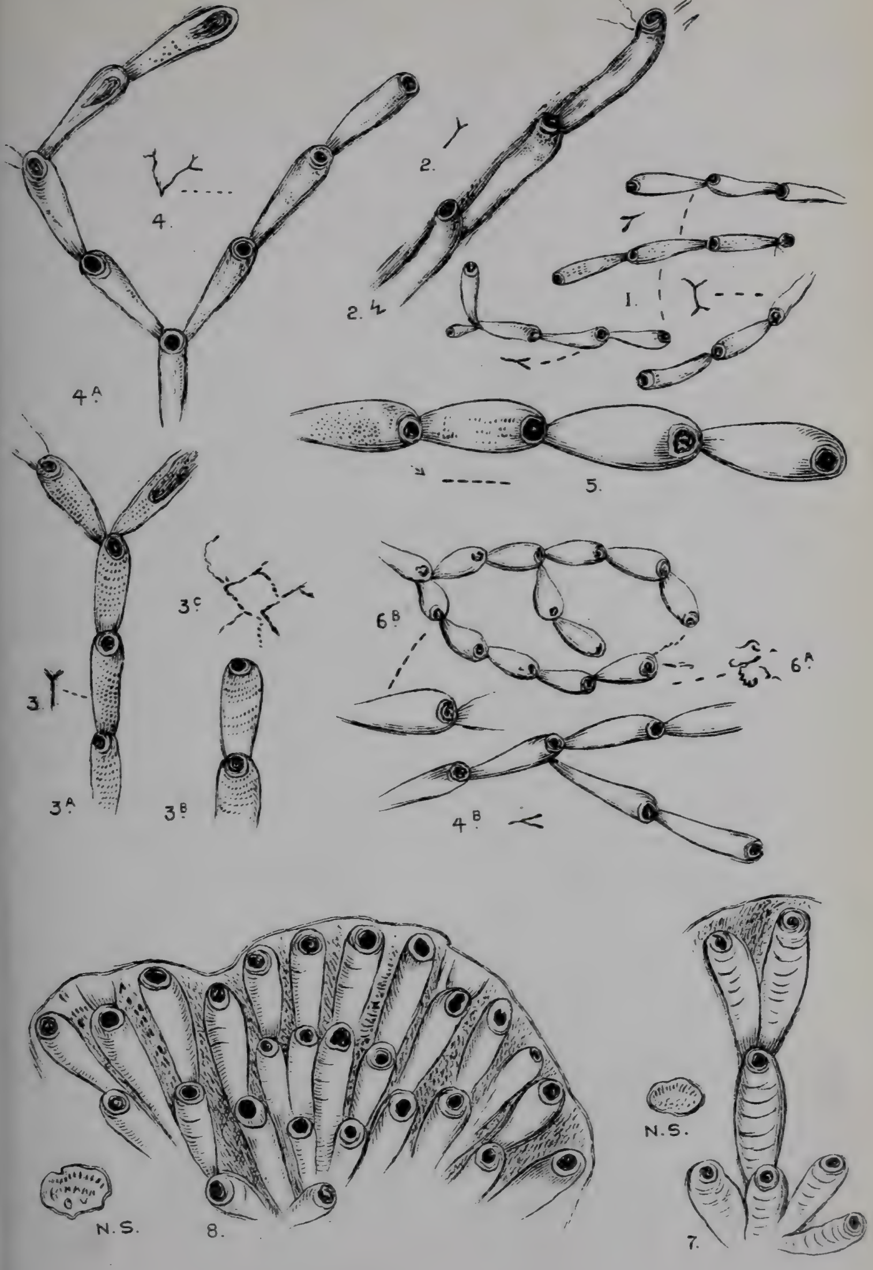
* Proc. Yorksh. Geol. and Polyt. Soc., vol. vii., pp. 1-11.

† Quart. Journ. Geol. Soc., vol. xliii., pp. 592-593, 1887.

Description of Plate.

1. Stomatopora gracilis, Edw., var. delicatula, Vine.
2. ,, ramea, Blainville.
3. ,, granulata, Edw.
4. ,, longiscata, d'Orb.
5. ,, linearis, d'Orb.
6. ,, divaricata, Rœmer.
7. Diastopora hunstantonensis, Vine. The central cells of a small colony.
8. Diastopora hunstantonensis, Vine. Var. A. Probably the D. contracta, Seeley.



Vine: Polyzoa and Microzoa.

Cretaceous Series in West Suffolk, the authors, Messrs. A. J. Jukes-Browne and W. Hill, remark as follows :—

" We are now in a position to indicate the bearing of our work on the debated question of the exact age of the Red Chalk. In the absence of anything like ordinary Gault, Upper Greensand, or Chalk Marl at Hunstanton, the remarkable stratum which there lies at the base of the Chalk has been referred by different observers to each of the formations which appeared to be missing, to the Gault by most of the early writers and by Mr. Wiltshire, to the Upper Greensand by Prof. Seeley (on the streugth of its fossils being similar to those of the Cambridge Greensand), and lastly to the Chalk Marl by Mr. Whitaker. Every one, however, has discussed the question principally from a local point of view, founding their arguments mainly upon a consideration of the rock and its fossils as seen at Hunstanton."

After stating their views rather more fully the authors seem to find a decisive answer to the question of age in the following premises :—

1. " That the Norfolk Gault becomes increasingly calcareous towards the north, till at Dersingham it passes into 7 feet of marly and chalky material. the lower part of which is coloured red.
2. That the microscopical structure of the Hunstanton Rock bears the same relation to the red and yellow marls of Dersingham that the hard chalk marl of Norfolk does to the softer Chalk marl of Cambridge.
3. That the hard whitish limestone which overlies the representative of the Gaults from Grimstone to Dersingham is identical, in our opinion, with the so-called " sponge-bed" which overlies the Red Rock at Hunstanton.
4. That the fossils are chiefly Gault species, and are such as would constitute a deep-sea fauna contemporaneous with that of the shallower and muddier water in which the Gault of South England was formed.

From these premises we come to the uncontrovertible conclusion that the Red Rock of Hunstanton must be the equivalent of the Gault, and not of its upper divisions only but that it is a condensed representative of both Lower and Upper Gault, formed outside of the limits of the area reached by mud-bearing currents."

In his concluding remarks in the "address" already referred to, Mr. Whitaker says, "From the evidence before us it seems to me that our Red Chalk is probably one of two things; either it is a part of the Lower Chalk or else it is a representative of that and of the upper part of the Gault. It is certainly chalk to some extent. Consequently, were I obliged to confess my belief in any one formation, I should simply say that Red Chalk is—Red Chalk." (p. 234, op. cit.)

II. DESCRIPTION OF THE POLYZOA.

In the two papers published in the Proceedings of this Society* I have described as fully as was possible the Polyzoa of the Cambridge Greensand. In presenting another paper on the Polyzoa of the Red Chalk of Hunstanton, it is only fair to state that a Monograph of the Polyzoa of the Red Chalk has already been published in the Journal of the Geological Society.† As, however, so many of my papers on Polyzoa have been read before the members of this Society and published in their Proceedings, one perfectly distinct from the other on the Red Chalk may not be deemed out of place. In the Monograph referred to only the new species that are described are figured, but though I have adopted D'Orbigny's names for some of the uniserial Stomatoporæ, the figures of the British examples may be produced with advantage to illustrate the present paper, but there will not be any need to re-describe the species except when additions or alterations are made.

Sub-Order CYCLOSTOMATA, BUSK.

A. Parallelata, Waters.

Zoaria encrusting, dendroid or anastomosing. Surface of *Zoarium* to a large extent formed of the lateral walls of Zoœcia.‡

Genus STOMATOPORA, Bronn.

1821. Alecto Lamouroux (Blainville, Johnston, Edwards and Busk).

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* 1885. Polyzoa of the Cambridge Greensand.—Proc. Yorksh. Geol. Soc., vol. ix
1889. Further Notes on the Camb. Greensand Polyzoa.—*Ibid.* vol. xi., p. 250.

† Quart. Journ. Geol. Soc., vol. xlvi., pp. 454—486.

‡ A. W. Waters, Quart. Journ. Geol. Soc., vol. xliii., p. 337.

1825. Stomatopora, d'Orbigny, for uniserial species.

Zoarium repent, adnate, or free at the extremities, uniserial, branching, and occasionally anastomosing.

In working out the uniserial Stomatoporæ of the Red Chalk, I have, generally speaking, followed the leading of d'Orbigny, but it is not always safe to adopt his names for British examples without some qualification at least.

1. Stomatopora gracilis, M. Edw. (Alecto), Ann. Sc. Nat. (9) p. 207, pl. 46, f. 2.

Var. delicatula (new. var.), pl. xvii., fig. 1.

1890. S. gracilis, Edw. (var.), Vine, Quart. Jour. Geol. Soc., vol. xlvi., p. 463.

Zoarium delicate, wholly adherent. *Branches* dichotomizing irregularly, and variable in breadth and length. *Zoœcia* uniserial, originating from a disc-like base from which two cells are generally thrown off, and these form the nucleus of two branches; slightly lateral in their points of juncture; aperture circular turning alternately to the left and right on the branch, and sometimes raised upwards.

Habitat: The most typical examples on *Terebratula biplicata.*

Typical *S. gracilis*, vary very much both in the Neocomian and in the Upper Chalk, so much so that one hesitates to put the forms under one name. In the variety described above, the delicate character of the Hunstanton forms, which, by the way, are most abundant, and adherent also to a variety of fossils, appear to me to warrant their seperation from the more robust species.

2. Stomatopora ramea, Blainville, pl. xvii., fig. 2-2a.

1834. Alecto ramea, Blainv. Man. de Actinozoa, p. 464, pl. 78, fig. 6.

1850. Alecto ramea, Lonsdale, Geol. of Sussex, p. 268, p. xviii., figs. 35-40.

1890. Stomatopora ramea, Vine. Quart. Jour. Geol. Soc., vol. xlvi., p. 465.

Examples of this species are rare in the Red Chalk. The Zoarium is, as Lonsdale says, uniserial, and the branching "irregularly divergent and nearly uniform in breadth, but bordered by a narrow band. *Zoœcia* nearly uniform in width, peristome inclined upwards, aperture circular ; when worn slightly oval.

Habitat : On *Terebratula biplicata*, Sby.

3. Stomatopora granulata, M. Edw., pl. xvii. fig. 3, 3a.b.c.
1838. Alecto granulata, Ed., Sur les Cris., &c., pl. xvi., figs. 3, 3a.
1875. Alecto granulata, Busk, Brit. Mus. Cat., pt. iii., pl. 32, fig. 1.
1880. Stomatopora granulata, Hincks, Brit. Marine Polyz., p. 425.
1889. Stomatopora granulata, Waters, Quart. Journ. Geol. Soc., vol. xliii., p. 341.
1890. Stomatopora granulata, Vine, Ibid., vol. xlvi., p. 464.

Zoarium variable in shape, and in the general arrangement of of its anastomosing branches, which are more or less linear. *Zoœcia* uniserial, almost uniform in breadth, oral extremity occasionally erect and free; cells punctured in the younger, granular in the older colonies. *Gonœcium* (?) a cell rather more inflated about the aperture than ordinary Zoœcia.

Habitat : On Inoceramus sp. and on *Terebratula biplicata*, Sby.

This species is not abundant in the Red Chalk, yet I have met with some fairish examples.

4. Stomatopora granulata (Edwards). Var. incrassata d'Orb.
1852. Stomatopora incrassata d'Orb., Terr. Cret., vol. v., p. 837, pl. 628, figs. 9-11.
1890. Stomatopora granulata, var. A, Vine, Quart. Journ. Geol. Soc., vol. xlvi., pl. 465.

The *Zoarium* of this variety is much more stunted, more compressed, and more anastomosing than the normal form. I follow Mr. Waters in identifying the *S. incrassata* d'Orb. as a variety of *S. granulata* Edwards, as, irrespective of size, the two have many features in common.

Habitat : On *Terebratula biplicata.*

5. Stomatopora longiscata d'Orb., pl. xvii., figs. 4a, b, c.
1852. Ibid d'Orb., Terr. Cret. v., p. 839, pl. 629, figs. 9-11.
1890. Stomatopora longiscata, Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 465.

Examples of this species are rare in the Red Chalk, but I have come across fragments that may be reasonably placed here. This is one of the species previously noticed by Mr. Wiltshire from the bottom layer (C) of the Red Chalk, and which he characterised as rare.

Habitat : On *Terebratula biplicata.*

6. Stomatopora divaricata, Roemer, pl. xvii., fig. 6a-6b

1840. Aulopora divaricata, Roemer, vol. ii., p. 15,, pl. 17,, fig. 3.

1850 = ? *Alecto brevis*, d'Orb., Terr. Cret., v., p. 840, pl. 629.

1890. Stomatopora divaricata, Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 463.

Adherent to a large number of fossils, many of them species of Inoceramus or Terebratula, is a peculiarly blunt, or stunted Stomatopora, figures of which are given. The forms are not unlike the so-called *Hippothoa inflata*, Hall, a Silurian species first brought to our notice, with admirable descriptions and figures, by Professor H. A. Nicholson.* In the Jurassic rocks there are similarly stunted forms, but as these have not been described I cannot refer to them more minutely. The Hunstanton examples of this species, if I am correct in my identification, are very characteristic ; and the figures, though sketched by the eye, may be relied on as pretty correct in outline. Detail sketches are not easy to obtain owing to the species being adherent to most of the larger fossils.

Habitat : Type of fig. on *Terebratula biplicata.*

7. Stomatopora linearis, d'Orb., pl. xvii., fig. 5.

1852. Stomatopora linearis, d'Orb., Terr. Cret., v., p. 838, pls. 629-658.

1890. Stomatopora linearis, Vine, Quart. Jour. Geol. Soc., vol. xlvi., p. 466.

I have met with only one unbranched specimen of this species in the Red Chalk of Hunstanton. The example differs from d'Orbigny's fig. in some respect, but only slightly. The *Zoœcia* of the British form are rather less oval than the French species of d'Orb.

Habitat : On *Terebratula biplicata.*

It may be well for the student to compare the British uniserial Stomatoporæ, as figured on plate xvii., with foreign examples figured by d'Orbigny, Reuss, and other authors, because, to prevent the loading of our literature with new names, injustice is too often done to our British fauna in adopting foreign names for species without a proper caution being given.

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* **Annal. Mag. Nat. Hist., s. 4, vol. xv., Feb , 1875, pl. xi., figs. 1-2.**

Genus Proboscina (Audouin) d'Orbigny.

The Genus *Proboscina* is a convenient, rather than an essential division of the Stomatopora group. As defined and accepted by d'Orbigny, the genus looses much of its individuality, for many of his species have been variously located by other authors. Mr. Hincks says (Brit. Marine Polyzoa, p. 432) "I do not venture to identify *Stomatopora expansa* with d'Orbigny's *Proboscina ramosa* (= *Idmonea cenomana* d'Orb.) though it bears a strong general resemblance to it," while *Tubulipora fimbria*, Lamk. (op. cit. p. 448) = *T. flabbellaris* Busk (Cyclostomata, p. 25) is identified by both authors as ? *Proboscina latifolia* d'Orb. In working up their material, both Mr. Busk and Mr. Hincks disallow the genus for recent species ; the latter author bracketing the Stomatopora whose zoaria are partially erect and free, as the Sub-genus *Proboscina* Smitt. *Stomatopora incrassata*, Hincks, thus absorbs *Tubulipora* (Proboscina) *incrassata* Smitt. *Alecto retiformis* Hincks, and ? *Filisparsa incrassata* D'Orb. From this it is manifest that unless the genus is more rigidly defined and limited, it would be impossible to accept it for the purposes of this memoir. By Reuss,* and Novak,† and recently by Mr. Walford‡ *Proboscina* has been accepted as a kind of passage genus intervening etween *Stomatopora* and *Diastopora*.

Jules Haime, in his admirable memoir on Jurassic Bryozoa, accepts *Proboscina* as a passage group, and he suggests that probably *Cellepora echinata*, Goldf. = *Tubulipora echinata*, Hag., and *Siphoniotyphlus plumatus*, Lonsdale, are really *Proboscina* species ; and *Diastopora ramosa*, Mich. Lonsd. is undoubtedly another. Haime, in his monograph, cites other species, and these are probably *Proboscina* Haime, = *Idmonea* (in part,) d'Orb.

Mr. E. O. Ulrich, in reviewing some of Prof. Nicholson's *Alecto* species,|| places two of them in the Proboscina group. Thus *Alecto confusa* Nich. and *Aulopora frondosa* James, become Proboscina respectively ; and Mr. Ulrich remarks that the Silurian forms are

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* **Bryozoen des Unteren Planers, in Geinitz's Ethalgel, in Sachsen, vol. 1, and Ibid, vol. ii.** † **Bryoz der böhmischen Kreideformation.**

‡ **Quart. Journ. Geol. Soc., vol. xliii., and Ibid, vol, xlv.**

|| **Ann. Mag. Nat. Hist., Ser, iv., vol. xv., 1875.**

like Stomatopora "but with cells in two or more series."* As yet I have not found multiserial-serial *Proboscina* in our own Silurian rocks, but the antiquity of the genus is sufficiently established by the citations already given.

From the above notes, all too brief, it will be gathered that there is a difficulty whenever we attempt to establish Proboscina as a natural division of the Stomatopora group : yet I find that in spite of these difficulties, that both in the Red Chalk and also in the Upper White Chalk the adoption of the genus is most convenient, but only in very rare cases are similarities even, much less identity, between British and foreign species noticeable.

The following species have been fully described in the paper already referred to, and as regards new species fully illustrated.

8. Proboscina angustata, d'Orb., Terr. Cret., p. 852, pl. 632, figs. 7, 9.

1890. Varieties (Vine) Quart. Jour. Geol. Soc., vol. xlvi., p. 467, pl. xix., 1, 1a.

1885. Stomatopora gracillis (?) Vine, Proc. Yorksh. Geol. Soc., vol. ix., p. 4, pl. ii., fig. 7.

Examples of this species are rare in the Red Chalk, and as they differ from the type species of d'Orb., I place them here temporarily.

Habitat : On *Terebratula biplicata.*

9. Proboscina rugosa (?) d'Orb.

1852. Proboscina rugosa d'Orb., Terr. Cret. p. 853, pl. 633, figs. 6, 7.

1890. ., ,, (?) Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 468.

Habitat : On Terebratula, Inoceramus and Ammonites.

10. Proboscina irregularis, Vine.

1890. Ibid. Quart. Journ. Geol. Soc. *Ibid*, p. 468, pl. xix., figs. 2a, 2b.

Var. A. Figs. 2c, 2d.

Habitat : On Terebratula and Belemnites.

This species is only known to me by a few rather imperfect examples besides the type species.

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* **Jour. Cincin. Soc. Nat. History, 1882, p. 149.**

11. Proboscina uberima, Vine., Quart. Jour. Geol. Soc., vol. xlvi., p. 469, pl. xix., figs. 3a-3b.

Habitat : On *Inoceramus? sulcatus.*

The type species is the only example that I have met with in the Red Chalk.

12. Proboscina gracilis, Reuss, var. Reussi, Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 469, pl. xix., figs. 4-4b.

Habitat : On *Terebratula biplicata.*

This species is also rare in the Red Chalk.

13. Proboscina subelegans, d'Orb., Terr. Cret. v., p. 853, pl. 759, figs. 8-13.

1890. Stomatopora subelegans, Pergens Rev. Bryoz. Cret., p. 332, pl. xi., fig. 3.

1890. Proboscina subelegans, Vine, Quart. Jour. Geol. Soc., vol. xlvi., p. 470.

Of this species I noticed in the material placed in my hands for description about three fairish examples only.

Habitat : On Inoceramus.

14. Proboscina hunstantonensis, Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 470, pl. xix., fig. 5.

Habitat : On Inoceramus and Terebratula biplicata.

This is by far the most characteristic and abundant of the Red Chalk Probiscinæ. The variety differs from the type species, but I find that it is impossible to seperate them altogether except by a varietal term.

15. Proboscina hunstantonensis, Vine. Var. ampliata, Vine, Ibid, pl. xix, figs. 6-6a.

Habitat : On Inoceramus.

Not so abundant as the typical form.

16. Proboscina Jessoni, Vine. Ibid, p. 471, pl. xix., figs. 7a-7b.

Habitat : On Terebratula biplicata.

This beautiful and well-marked species is rare in the Red Chalk. It is not often that we meet with examples of *Proboscina* having the orifices of the cells closed, but in this species several of the middle cells of the colony have not only closed cells, but the "closures" are delicately perforated.

17. Proboscina gigantopora, Vine. Ibid, p. 471, pl. xix., figs. 8-8b.
Reference : Entalophora gigantopora (Proboscidian stage), Vine, Camb. Greensand Polyzoa, Proc. Yorksh. Geol. Polyt. Soc., vol. ix., 1885, p. 8, pl. i., fig. 3, and vol. xi., 1889, p. 262, footnote.
Habitat : On *Terebratula biplicata.*

18. Proboscina bohemica (?), Novák. Var. (Vine) Op. cit., p. 472, pl. ix., figs. 9a-9b.
1877. P. bohemica, Novák, Bryoz., Böhm, Kreidef, p. 101, pl. v., figs. 24-25.
1852 (?). Idmonea radiolitiorum d'Orb., Terr. Cret. v., pl. 633, figs. 8-10.

A beautiful little polyzoon, and closely resembling Novák's species.
Habitat : On *Terebratula biplicata.*

19. Proboscina Toucasiana (?), d'Orb., Terr. Cret. v., p. 856, pl. 634, figs. 1-6.
1890. Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 472.
Habitat : On Terebratula biplicata.

20. Proboscina ramosa (?) d'Orb., Terr. Cret. v., p. 851, pl. 632, figs. 1-3, pl. 633, figs. 1-3. Vine, Quart. Journ. Geol. Soc., xlvi., p. 473.
Habitat : On Inoceramus.

21. Proboscina dilitata, d'Orb., Terr. Cret., v. p. 851, pl. 632, figs. 4, 6.

Prof. Seeley remarks of this species that the fossil is about intermediate between d'Orbigny's figures of *Idmonea dilatata* and *Idmonea virgula*, being nearer to the former. It appears to differ a little too, in having the mouths more contracted. Ann. Mag. Nat. Hist. Ser. iii., vol. xvii., p. 181, 1866.

22. Proboscina dilitata var. cantabrigiensis, Vine, Quart. Jour. Geol. Soc., vol. xlvi., p. 473.
1889. P. dilitata var. cantabrigiensis, Vine.
Further Notes on the Polyzoa of the Cambridge Greensand. Proc. Yorksh. Geol. Soc., vol. xi.
1890. Ibid., Vine. Quart. Jour. Geol. Soc.. vol. xlvi., p. 473.
Habitat : Red Chalk. Cast only.

So far as I am concerned all that I have seen at all resembling the *P. dilitata*, d'Orb., is a cast of a species similar to the one referred to in my Greensand paper. Its existence, however, is recorded by Prof. Seeley in his 1864 paper, and by the Rev. T. Wiltshire, but marked rare (top layer Red Chalk). Therefore I retain d'Orb. name, so as to admit the identifications of Prof. Seeley and the Rev. T. Wiltshire.

Genus DIASTOPORA Lamx.

The Diastopora of the Red Chalk are a very peculiar and a very characteristic group of fossils. Most of the species now to be referred to are altogether unlike any known British forms, but some are evidently allied to species described by d'Orbigny and other authors, derived from foreign Cenomanian or Senonian horizons; while others, such as *D. hunstantonensis* and its allies are quite distinct and new to science.

As already stated Prof. Seeley has catalogued (1864) three species, *Berenicea polystoma* Rœm; *B. contracta* Seeley; and *B. clementina* d'Orb;* but in his 1866 paper only one species, *B contracta* Seeley is described. It is quite possible that this form may be one of the varieties of *D. hunstantonensis* Vine, of which species there are several varieties, and as no figures are given by the author it may be well to retain it, below which Mr. Seeley's remarks will appear. The other species I have not been able to identify. The *Cellulipora sulcata* Seeley will be retained as Diastopora, but I am not aware that I have come across a similar species in the Hunstanton Red Chalk. As Prof. Seeley's fossils are preserved in the Woodwardian Museum, probably labelled with the specific term *sulcata*, I feel that I have no right to suppress it in this memoir.

23. Diastopora hunstantonensis, Vine. Fig. 7 (small example).

1890. D. hunstantonensis, Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 475, pl. xix., figs. 10a, 10b.

This is the most abundant and most characteristic of all the Red Chalk Polyzoa. I have found examples of it adherent to a large number and variety of fossils, especially the larger Ammonites. On one Ammonite alone I counted more than a dozen colonies, but I was unable to study these forms under the microscope on account of the size of the Ammonite, and in examining them by the hand glass, which was by no means satisfactory, I might have overlooked several varieties, and the *D. contracta* Seeley, might be one of the forms that has not been previously recorded by me. It will be noticed in my list of *Proboscina* species that one bears the name *P. hunstantonensis*, Vine; evidently the Probiscina thus named is an ally of the present form.

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* 1864 Ann. Mag. Nat. History.

Habitat : On Terebratula, Inoceramus, Ammonites, and almost on every class of fossils referred to.

24. Diastopora hunstantonensis, Vine. (Var. A.) fig. 8, Quart. Jour. Geol. Soc., p. 475, pl. xix., figs. 11a, 11b.

A well-marked variety of this beautiful species.

Habitat : On Inoceramus and Terebratula

25. Diastopora hunstantonensis, Vine.

? Var. *contracta*, Seeley. Ann. Mag. Nat. Hist., Ser. iii., vol. xvii., p. 181, 1866.

Prof. Seeley remarks that the species which he has described as *Berenicea contracta*, "resembles *Diastopora clementina* d'Orb. (Terr. Cret. v., p. 865, pl. 636, figs. 1, 2), of which it is a good variety. It is attached, *orbicular*, and has the cells arranged like an extended fan ; these are very distinct and narrow, being about twice as long in proportion to their width, as in *B. clementina*, and contract from the point where they first appear, to the aperture, which is very small. This tapering character of the cells suffice to distinguish it from all other forms."

26. Diastopora fœcunda, Vine.

1885. Diastopora fœcunda, Vine, Proc. Yorksh. Geol. Polytech. Soc., vol. ix., p. 9.

1889. Diastopora fœcunda, Vine, Ibid, vol. xi., p. 266.

1890. Diastopora fœcunda, Vine, Quart. Jour. Geol. Soc., vol. xlvi., p. 476.

The Red Chalk form is rather larger than the one described in the Cambridge Greensand papers.

Habitat : On a Water-worn piece of Chalk.

27. Diastopora regularis, d'Orb.

1850. D. regularis d'Orb., Terr. Cret. v., pl. 636 (fig. 10 only).
1851. D. densata d'Orb., ibid, pl. 637, figs. 1, 2.
1851. D. orbicula d'Orb., ibid, pl. 637, figs. 3, 4.
1852. Berenicea regularis d'Orb., p. 865, ibid, pl. 636, figs. 9, 10, pl. 637, figs. 3, 4.
1869. ,, ,, Wiltshire, Ann. Mag. Nat. Hist., vol, xxv., p. 187.
1890. Diastopora regularis Vine, Quart. Jour. Geol. Soc., vol. xlvi., p. 476.

A well-marked and characteristic species as restricted above, and the only one that I have met with.

Habitat: On *Terebratula biplicata.*

28. Diastopora radians Novák., Variety ?

1877. Berenicea radians Novák, Bryoz. böhm. Kreidef., p. 98, pl. iv., figs. 15, 18.
1890. Diastopora radians ? Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 477.

The example which I place under Novák's name, as a variety of his species, is the only one that I have met with amongst the Red Chalk fossils.

Habitat: *Terebratula biplicata.*

29. Diastopora papillosa (?) Reuss.

1846. Diastopora papillosa, Reuss. Verst. böhm. Kr., p. 65, pl. xv., figs. 44, 45.
1847. ,, papillosa, d'Orb., Prodr. ii., p. 266.
1847. ,, oceanica, d'Orb., ibid.
1851. ,, disciformis, Hag. Bryoz. Maastr. Kreid., p. 16, pl. x., f. 7.
1852. Berenicea papillosa, d'Orb., Terr Cret. v., p. 866, pl. 639, figs. 6, 7.
1890. Diastopora papillosa, Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 477.

The Red Chalk form is disciform, one colony overlapping another, originating cells central.

Habitat: On *Terebratula biplicata.*

30. Diastopora Jessoni, Vine.

1890. Diastopora Jessoni, Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 478, pl. xix., figs. 12a, 12b.

This beautiful little species is only known to me by a few examples, the most perfect of which is taken as the type.. My reasons for naming it after Mr. Jesson are given in the descriptive text in the Quart. Journ. Geol. Soc., p. 478.

Habitat : On *Tertebratula biplicata* ; *Nautilus albensis,* d'Orb.

31. Diastopora sulcata, Seeley.

1866. Cellulipora sulcata, Seeley, Ann. Mag. Nat. Hist., vol. xvii, p. 181.

"The form of the colony in this species is similar to that of *Cellulipora spongiosa*, d'Orb. (D. spongiosa, d'Orb., 1850, Terr. Cret. v., p. 874, pl. 637, f. 5, 6), with which it is most closely related. . . *D. Sowerbyi*, Lonsdale, belongs to this genus (Cellulipora), and is nearly related, and may even be this species, but from the important characters being overlooked in the description and figure, I cannot determine the point." Seeley.

32. Unitubigera papyracea, d'Orb.

1850. Actinopora papyracea, d'Orb.

1852. Unitubigera papyracea, d'Orb., Terr. Cret. v., pl. 643, figs. 12, 14.

1890. ,, ,, Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 479.

This species is rare in the Red Chalk, but the example that I place here, though almost unique, is very distinct. Only one other broken specimen has been found.

Habitat : On *Terebratula biplicata.*

Genus ENTALOPHORA, Lamx.

The following may be recorded but examples are very rare, and very ill preserved.

33. Entalophora proboscidea, Edw.

1890. Entalophora ? sp. Quart. Journ. Geol. Soc., xlvi., p. 479.

Habitat : On Spondylus. Red Chalk, Hunstanton.

It is useless to give any synonyms of the above species in this case, as I am somewhat doubtful about the identity of this ill-preserved example, but I believe that I am right.

§ B. RECTANGULATA, Waters.

In which the Zoœcia or cancelli open for the most part at right angles to the axis or surface of the Zoarium or sub-colony.

Genus CERIOPORA, Goldfuss.

1826. Ceriopora (pars.) Goldf. : Petrifacta, &c.

In establishing the genus *Ceriopora,* Goldfuss accepted for his type Alveolites, Lamarck ; altogether Goldfuss described about 37 species, but since his time the genus has been broken up considerably. d'Orbigny admits (Terr. Cret. v., p. 1030) the following Cretacous species :—

1830. Ceriopora tubiporacea, Goldf., Petrifacta, pl. x., f. 13.
,, ,, milleporacea ,, ,, pl. x., f. 10.
,, ,, micropora ,, ,, pl. x., f. 4.
1845. Ceriopora truncata, Mich. Icon., pl. li., f. 7.

34. Ceriopora micropora ? Goldf. (Vine), Quart. Journ. Geol. Soc., vol. xlvi., p. 480.

Two examples of this species were found among the fossils submitted to me for examination.

Habitat : Embedded in fragments of Red Chalk.

Horizon : Middle Bed, Hunstanton.

Genus REPTOMULTICAVA, d'Orb.

1826. Ceriopora (pars.) Goldfuss ; Blainville.
1852. Reptomulticava, d'Orb., Terr. Cret. v., p. 1032.

35. Reptomulticava simplex, d'Orb., Terr. Cret. v., p. 1041, pl. 793, fig. 5.

Habitat : On *Terebratula biplicata.*

36. Reptomulticava collis, d'Orb., Terr. Cret. v., p. 1036, pl. 792, figs. 1, 3.

1890. *R. simplex* and *R. collis*, Vine, Quart. Jour. Geol. Soc., vol. xlvi., p. 481.

37. Reptomulticava mamilla, Rss. (Wiltshire).

1869. Quart. Jour. Geol. Soc., vol. xxxv., p. 187.

Horizon : Middle and Lowest layers. Red Chalk, Hunstanton. (Common, Wiltshire).

38. Reptomulticava favus, Seeley.

1866. Ann. Mag. Nat. Hist., Ser. iii., vol. xvii., p. 181.

A form, says Prof. Seeley, nearly related to *R. collis* and *R. mamilla*, but irregular in growth, more resembling d'Orb's *Ceriopora digitata*. It is a common fossil and may be marked *R. favus*.

Although I only admitted two species of *Reptomulticava* (Nos. 35 and 36) in my paper, the other two may be advantageously adopted. I have retained Prof. Seeley's name, however, as most appropriate for one of the undescribed examples in my cabinet.

Habitat : On Fragments of Water-worn Red Chalk.

Horizon : Top layer (*A.*) *Hunstanton.*

Genus ZONOPORA.

D'Orbigny in his 5th Family Caveidæ (Terr. Cret. v., p. 922) has brought together no fewer than twenty-seven genera, all of which are peculiar, or characteristic. The author includes in this family, Zonopora, Ditaxia, Lichenopora, Domopora and Radiopora. In his "Revision des Bryozoaires du Crétacé figures par d'Orbigny," Dr. Pergens,* these genera are separated, and Zonopora and Multicrescis are designated Heteropora. For the convenience of reference, and to prevent any misinterpretation in the present paper of the Monograph of Red Chalk Polyzoa (Q. J. G. Soc., vol. xlvi), I quote the names given in the latter paper, with the additional references furnished by Dr. Pergens in his Revision.

39. Zonopora irregularis, d'Orb.

1840. Zonopora irregularis, d'Orb., Prodr. ii., p. 87.

1852. ,, ,, d'Orb., Terr. Cret. v., p. 390, pl. 771, figs. 4, 6.

1890. Heteropora arborea Koch. et Dunker. (Pergens.) Revis. des Bryoz., p. 373.

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* Bulletin de la Soc. Belge de Geol. de Palæontologie, 1889, Tome iii., pp. 305, 400.

1890. Zonopora irregularis (?) Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 482.

Habitat : Embedded in Red Chalk.

Horizon : Top layer (A.) Hunstanton.

40. Zonopora variabilis (?), d'Orb.

1852. Zonopora variabilis, d'Orb., Terr. Cret., v., p. 931, pl. 771, figs. 9-13.

1890. Heteropora variabilis, Perg., Rev. des. Bryoz., p. 374.

1890. Zonopora variabilis (?), Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 482.

Two minute fragments are placed here doubtfully.

Horizon: Top layer (A.) Red Chalk, Hunstanton.

41. Multicrescis variabilis, d'Orb., Terr. Cret. v., p. 1077, pl. 800, figs. 3-7.

1890. Multicrescis variabilis, Vine, Quart. Journ. Geol Soc., vol. xlvi., p. 483.

Horizon: Top layer (A) Red Chalk, Hunstanton.

42. Heteropora tenera. Hagenow, var.

1890. Heteropora (?) sp., Vine, Quart. Journ. Geol. Soc., vol. xlvi., p. 480.

I am rather doubtful about this species, as the fragments were very soft and did not yield good results when rubbed down for minute examination. Yet I have had fragments of Faringdon *H. tenera* just as doubtful to deal with, but being of a harder texture better results were obtained by rubbing.

Habitat : Decumbent on Water-worn Hunstanton Red Chalk.

43. Lichenopora collis, d'Orb.

1850. Actinopora collis, d'Orb., Terr. Cret. v., pl. 643, fig. 1-4.

1852. Unicavea collis, d'Orb., Ibid. p. 973, pl. 778, fig. 1-2.

1890. Unicavea collis, Vine, Quar. Journ. Geol. Soc., vol. xlvi., p. 483.

This species must not be confounded with *Reptomulticavea collis*, d'Orb., already described.

Habitat : On Terebratula, Inoceramus, and Bourgueticrinus.

I have found two varieties of this species among my Red Chalk material.

§ II. Sub-Order CHEILOSTOMATA, Busk.

Species belonging to this sub-order are very rare in the Red Chalk The five well-marked species given below, are all that I have met with, and these are very fragmentary. Excepting the first, which is new, I have identified the other species to the best of my ability, but I think they ought to find a place here in the hope that better examples will be found in the future.

44. Membranipora gaultina, Vine, Quart. Jour. Geol. Soc., v. xlvi., p. 484, pl. xix., figs. 13a-13b.

Habitat: On Inoceramus, Terebratula biplicata, and T. capillata.

Horizon: Gault, Cambridge; Red Chalk, Hunstanton.

45. Membranipora fragilis, d'Orb.

1852. Flustrellaria fragilis, d'Orb., Terr. Cret. v., p. 545, pl. 723, figs. 5-9.

1890. M. fragilis, Vine, Quar. Journ. Geol. Soc., p. 485.

Habitat: On Terebratula biplicata, Red Chalk, Hunstanton.

46. Membranipora? obliqua, d'Orb.

1852. Filiflustrellaria obliqua, d'Orb., Terr. Cret., v., p. 513, pl. 723, figs. 1-4.

1890. M. obliqua? Vine, Q. J. Geol. Soc., vol. xlvi., p. 485.

The fragment, adherent to *Belemnites minimus,* is the only example of this species known to me from the Red Chalk of Hunstanton.

47. Membranipora elliptica? Hagenow.

Cellepora elliptica, Hag. Marginaria elliptica, Rœm.

Membranipora elliptica, d'Orb.

1877. M. elliptica, Novák, Bryoz. böhm, Kreide, p. 89, pl. 2, fig. 16.

Hesitating, as I do, to identify this species with von Hagenow's *C. elliptica,* I refer the student, with pleasure, to the long list of synonyms and references given by Novák. I have only one example, and as Novák's fig. 16, pl. ii., closely resembles its general features, his identification is adopted.

Habitat: On *Pentacrinus Fittoni*, Red Chalk, Hunstanton.

48. Hippothoa? simplex, d'Orb.

1851. Hippothoa simplex, d'Orb. Terr. Cret., v., p. 385, pl. 711, figs. 5-8.

1890. Hippothoa simplex, Vine, Q. J. Geol. Soc., vol. xlvi, p. 486, very rare in the Red Chalk.

Habitat : On Inoceramus, Red Chalk, Hunstanton.

In my Monograph of the Polyzoa of the Red Chalk* of Hunstanton I have only catalogued 43 species and varieties, the additional 5 species or varieties in this paper are made up chiefly from the identifications of other authors, which, I consider it would be unwise to suppress.

III. Entomostraca.

When examining the material sent to me by Mr. Jesson, every now and again I came across fragments of broken chalk, or broken shell, on which were examples of either Ostracoda or Foraminifera. At least four or five species were found in this way, but as I did not intend to work out these two groups when I had the polyzoa paper in hand, I returned the attached forms to Mr. Jesson with the other unused fossils. Most of the Entomostraca, so far as I remember, belonged to the *Cytherella* and probably *Bairdia* groups, and the Foraminifera were *Lituola* and *Cristellaria* species. Among the rest of the material sent to me was a small box of powdered fragments of Red Chalk from the top layer of the Hunstanton bed. This I reserved for the purpose of manipulation, and after washing and sifting I was able to pick out the Microzoa, which will be described in this part of my paper. Neither Foraminifera nor Entomostraca were in any abundance, in many cases the examples that will be referred to are unique. Occasionally I came across a small fish tooth or a minute fragment of Echinodermata, spines chiefly, which I am not able to describe, but their presence may receive a passing notice. Thin sections of the Red Chalk of Speeton and Hunstanton, together with sections of White Chalk from the layers which overlay the Red Chalk of Speeton and Hunstanton have been carefully prepared and examined for the purpose of studying the difference between the red layers of Norfolk and Yorkshire. Examples of the Lincolnshire Red Chalk I was not able to get.

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* Quart. Journ. Geol, Soc., vol. xlvi., 1890.

It must not be imagined, therefore, that this part of my paper is in any way exhaustive; indeed our knowledge of the Microzoa of the Red Chalk is only in its infancy, but every little addition to that knowledge will help in a good work, and others may benefit by even a single record. As regards the Entomostraca my chief references will be to Prof. T. Rupert Jones' Monograph of Cretaceous Entomostraca;* and to the Suplementary Monograph recently published by Messrs. T. R. Jones and G. H. Hinde.† In the 1849 Monograph only one species, *Cytherella ovata*, is recorded as derived from the Red Chalk of Flamborough: in the second Monograph none are recorded, not even the *C. ovata* as above. I am, glad therefore, to be able to add to the Red Chalk list five additional species.

Genus BAIRDIA, M'Coy.

1. Bairdia sub-deltoidea, Münster.

1849. Bairdia sub-deltoidea, Jones, Monog. Entom. Cret. p. 23, pl. v., fig. 15.
1856. Bairdia sub-deltoidea, Jones, Monog. Entom. Tert., p. 52.
1890. ,, ,, Jones and Hinde, Monog. Entom. Cret. p. 5, pl. ii., figs. 31-34.

A long list of synonyms and references is given by the authors in the last (1890) citation above, p. 5, to which the student is referred. The unique example which I place here is more like the fig. 34 (right valve), pl. ii., (Monog. Entom. Cret., J. and H.), than any of the others in this, or in the earlier Monograph.

Localities (Jones and Hinde).

Chalk: Norwich, Horstead, Colchester, and South East England; Cave Hill (Antrim), and Keady Hill (Londonderry).
Chalk-rock: Dunstable and Luton (Bedfordshire); West Wycombe (Buckinghamshire); Chinnor (Oxfordshire).
Chalk-Marl: Didcot (Berkshire); *Detritus*: Charring (Kent).
Red Chalk Hunstanton, Vine.
Gault: Godstone (Surrey); *Greensand*: Cambridge and Warminster.

2. Bairdia Harrisiana, Jones.

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* Palæontographical Soc., 1849.

† Palæontographical Soc., 1890.

1849. Bairdia Harrisiana, Jones. Monog. Entom. Cret., p. 25.
1890. „ „ J. and H., Monog. Entom. Cret., p. 8, pl. ii., figs. 52-55.

The examples which I place here are like the Cambridge Greensand forms in my possession, "elongate, convex, and narrow," which were at first identified by Prof. T. R. Jones as "Argillæcia? Harrisiana."

Localities: *Chalk:* Keady Hill (Derry); Gravesend and Charlton (Kent); *Chalk Rock:* Dunstable; *Detritus:* (Charing); *Red Chalk Hunstanton* (Vine); *Greensand:* Cambridge; *Gault:* Folkestone and Leacon Hill.

Genus Cythereis, Jones, 1849.

3. Cythereis auriculata (Cornuel) (fig. 53, more particularly J. and H., pl. i.)

Cythere auriculata Corn. (part) Mem. Soc. Geol. France.
1890. Cythereis auriculata J. and H., Monog. Entom. Cret., p. 19, pl. i., figs. 56-61.

"Specimens of this particular form have been obtained by Mr. F. Chapman, from the Gaults of Folkestone (Kent), and Godstone (Surrey). Figs. 53 and 64 are typically sub-oblong, broadly rimmed and denticulate in front, and bear the two longitudinal swellings characteristic of this species." p. 20, op. cit). The unique Red Chalk form bears the longitudinal swellings, and speaking generally all the other features depicted in fig. 53 on pl. i.

Localities: *Chalk Rock*: Dunstable; Red Chalk Hunstanton: *Gault*: Godstone and Folkestone; *Neocomian*: Haute-Marne, France.

4. Cythereis Lonsdaleana Jones. Monograph, Cret. Entomos. Jones and Hinde, 1890, pl. i., p. 27 for description.

I have found a single valve of this species which corresponds with fig. 64, pl. i., of the above monograph.

Horizon: Red Chalk, Hunstanton (Top bed).

Genus Cytherella, Jones, 1849.

5. Cytherella ovata, Rœmer (Monog. Cret. Entom. Jones, 1849).

1890. See Monog. Entom. Cret. J. and H., pp. 44-45, pls. iii., iv.

Horizon: Red Chalk Hunstanton (Vine); Flamborough (Jones).

6. Cytherella Muensteri (Römer) 1849. Monog. Entom. Cret. 1890. Monog. Entom. Cret. J. and H., p. 46 for references, &c.

Horizon: Red Chalk Hunstanton.

IV. Foraminifera.

It will not be necessary to give elaborate details of the Foraminifera of the Red Chalk. Some of the examples are unique, but nearly all of them belong to the ordinary chalk forms, and with the exception of three are similar to the species already catalogued from the Cambridge Greensand.

1. Placopsilina cenomana d'Orb.

Examples of this genus, which are, according to Prof. T. R. Jones (Fossil Foraminifera Brit. Mus., p. 87, fixed *Lituola,*) are abundant in the Red Chalk, adherent to a variety of fossils.

Horizon, &c.: Red Chalk Hunstanton: On *Terebratula biplicata.*

2. Nodosaria obscura, Reuss.

Unique example.

Horizon: Red Chalk Hunstanton,* Middle layer B.

3. Cristellaria rotulata, Lam.

This species is very small and rather rare in the Red Chalk. In the Cambridge Greensand (Phosphate Beds) it literally swarms in the *débris*, and examples may be picked out by thousands.

Horizon: Red Chalk Hunstanton. Top layer A. and sections in the Middle layer B in chalk; Red Chalk Speeton (Yorkshire).

4. Bulimina presli, Reuss.

Examples rather rare.

Horizon: Red Chalk Hunstanton. Mid. layer B, and top layer A.

5. Verneuilina triquetra Münster. (V. tricarinata, d'Orb.)

Horizon: Red Chalk Hunstanton, Top layer A, rare. Camb. Greensand: abundant.

6. Globigerina bulloides, d'Orb.

This form is very abundant in sections of Red Chalk from both

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* I could quote a variety of horizons for the species indicated, but I have kept to my own labours chiefly.

Hunstanton and Speeton. The Speeton forms, however, are considerably larger in the chambers than in the Hunstanton Red Chalk. and I find examples of the species in sections from the whole of the layers A, B, C. In the finely sifted *débris* of the middle and top bands, mounted as transparencies of course, I also met with small examples. At Speeton, in sections of the chalk which overlie the Red Bed, and also at Hunstanton, the *G. bulloides*, as well as the next species, are common.

Horizons: Red Chalk, Hunstanton and Speeton; White (or grey) Chalk over Red Chalk, Hunstanton and Speeton: Cambridge Greensand (Phosphate Beds).

7. Globigerina cretacea, d'Orb.

Found under similar circumstances as No. 6.

Horizons: Same as No. 6.

8. Planorbulina ammonoides, Rss.

Rare otherwise than in sections of Red Chalk.

Horizons: Red Chalk, Speeton and Hunstanton; Camb. Greensand.

9. Rotalia Beccarii, Linn.

I believe that this species has only once before been found in the Chalk, by Mr. Joseph Wright. Mr. Sherborn says "The *Rotalia Beccarii* is most important, and as far as I can see unassailable."*

Horizon: Red Chalk Hunstanton, Top Band A.

Only on the day before the presentation of my paper to the Yorkshire Geological Society (Nov. 4th, 1890), I received from Mr. C. D. Sherborn, a copy of his elaborate paper on the Foraminifera of the Red Chalk of Yorkshire, Norfolk, and Lincolnshire.† This is a valuable contribution to the literature of the Foraminifera, especially so on account of the four plates of illustrations of the species described. My own work, however, as given above, was prepared altogether independently of the knowledge that other authors were working on the group. After the publication of the paper referred to below, I sent the dry mounted slides to Mr. Sherborn for examination, so as to prevent misinterpretation of species on my part, consequently I have altered two names in deference to his authority. I have also obtained Mr. Sherborn's sanction to publish the very full list of Red Chalk Foraminifera found in Yorkshire, Lincolnshire, and Norfolk, which is the result of several years labour on the group by the author's whose names are associated with his on the title page of the paper. For special details the student is referred to the paper itself. I believe a second paper is in hand.

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* The slide containing nearly all the species of Foraminifera and Entomostraca described or referred to above has been given to the Brit. Museum (S. Kensington), and many of the Foraminifera described by Mr. Sherborn are, I believe, also placed in the Museum.

† By H. W. Burrows, C. Davies Sherborn, and the Rev. George Bailey. Journal of the Royal Microscopic Soc. (1890), pp. 549-566.

Full lists, up to date Nov. 10th, 1890, of the Foraminifera, Entromostraca and Polyzoa of the Red Chalk of Norfolk, Lincolnshire, and Yorkshire (Speeton).

I.—FORAMINIFERA.

1826. Spiroloculina, d'Orbigny.
,, papyracea sp. nov. (B. S. and Bailey).
,, tenuis, Crjzek (and Brady).
1858. Miliolina, Williamson.
,, sp. (Young forms of *S. tenuis*? Sherb., op. cit., p. 552).
1840. Placopsilina, d'Orb. (fixed Lituola).
,, cenomana, d'Orb.
1854. Cornuspira, Schultze.
,, cretacea, Reuss.
1861. Ammodiscus, Reuss.
,, gordialis, Jones and Parker (= *Trochamini id.*).
,, incertus, d'Orb. (= *Operculina*).
,, tenuis, Brady.
1824. Textularia, Defrance.
,, attenuata, Reuss.
,, pygmœa, Reuss.
,, agglutinans, d'rOb.
,, gramen, d'Orb.
,, trochus, d'Orb.
,, turris, d'Orb.
,, complanata, Reuss (= *Proroporus id.*).

1840. Verneuilina, d'Orbigny.
    ,, propinqua, Brady.
    ,, triquetra (Münst).
1844. Spiroplecta, Ehrenberg.
    ,, biformis, Parker and Jones.
1840. Gaudryina, d'Orbigny.
    ,, pupoides, d Orb.
1826. Bulimina, d'Orbigny.
    ,, affinis, d'Orb.
    ,, Presli, Reuss.
1839. Bolivina, d'Orbigny.
    ,, textularioides, Reuss.
    ,, Beyrichi, Reuss.
    ,, sp. (near B. punctata, d'Orb.)
1859. Pleurostomella, Reuss.
    ,, subnodosa, Reuss.
    ,, alternans, Schwager.
1784. Lagena, Walker and Boys.
    ,, globosa (Mont).
    ,, lævis (Mont).
    ,, apiculata, Reuss.
    ,, ,, var. emaciata, Reuss.
    ,, cincta Seguenza.
1816. Nodosaria Lamarck. = (1826) Glandulina, d'Orb.
    ,, lævigata, d'Orb.
    ,, obtusissima, Reuss.
    ,, cylindracea, Reuss.
    ,, candela, Egger.
    ,, simplex, Silvestri.
    ,, longiscata, d'Orb.
    ,, calamorpha, Reuss.
    ,, limbata, d'Orb.
    ,, obscura. Reuss.
    ,, prismatica, Reuss.
1826. Dentalina, d'Orb. (Nodosaria continued, Sherborn)
    ,, soluta, Reuss.

1826. Dentalina communis, d'Orb.
,, brevis, d'Orb.
,, filiformis, d'Orb.
,, marginuloides, Reuss.
,, mucronata, Neugeboren.
,, abnormis, Reuss.
1826. Marginulina, d'Orbigny.
,, glabra, d'Orb.
,, inequalis, Reuss.
,, variabilis, Neugeb.
1826. Lingulina, d'Orbigny.
,, carinata, d'Orb.
1824. Frondicularia, Defrance.
,, biformis, Marsson
,, gaultina, Reuss.
,, Archiaciana, d'Orb.
1860 Rhabdogoniam, Reuss.
,, tricarinatum (d'Orb).
1826. Vaginulina, d'Orbigny.
,, eurynota, Reuss.
,, recta, Reuss.
,, arguta, Rss.
,, legumen, Rss.
1816. Cristellaria, Lamarck.
,, rotulata, Lam.
,, cultrata, Montf.
,, gibba, d'Orb.
,, italica, Defr.
,, lata, Rss.
,, variabilis, Rss.
,, multiseptata, Rss.
,, crepidula (F. and M).
,, Marckii, Rss
,, cymboides, d'Orb.
1826. Polymorphina, d'Orbigny.
,, lactea (Walker and Jacob).

1826. Polymorphina communis, d'Orb.
,, amygdaloides, Rss.
,, gibba, d'Orb.
,, horrida, Rss.
1875. Ramulina, Rupert Jones.
,, aculeata, d'Orb.
1826. Globigerina, d'Orbigny.
,, bulloides, d'Orb.
,, cretacea, d'Orb.
1816. Rotalia, Lamarck. (Rotalina, Linne, 1767).
,, Beccarrii (Linne).
1839. Orbulina, d'Orbigny.
,, universa, d'Orb.
1826. Sphœroidina, d'Orbigny.
,, bulloides, d'Orb.
1826. Truncatulina, d'Orbigny.
,, variabilis, d'Orb.
1826. Planorbulina, d'Orbigny.
,, ammonoides, Rss.
1862. Pulvinulina, Parker and Jones.
,, menardii, d'Orb.
1826. Anomalina, d'Orbigny.
,, grosse-rugosa, Gümbel.
1822. Polystomella, Lamarck.
,, macella (F. and M).

II. ENTOMOSTRACA.

1844. Bairdia, M'Coy.
,, subdeltoidea, Münster.
,, Harrisiana Jones.
1849. Cythereis, Jones.
,, auriculata, Cornuel.
,, Lonsdaleiana, Jones,
1849. Cytherella, Jones.
,, ovata, Rœmer.
,, Muensteri, Rœmer.

III. POLYZOA, (=*Bryozoa.*)

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§ CYCLOSTOMATA, Busk.

Stomatopora gracilis, Edw. var. delicatula, Vine.
,, divaricata, Rœmer.
,, granulata, Edwards.
,, ,, var. incrassata, d'Orb.
,, ramea, Blainville.
,, longiscata, d'Orb.
,, linearis, d'Orb.
Proboscina angustata, d'Orb.
,, rugosa (?) d'Orb.
,, irregularis, Vine.
,, ,, Var. A., Vine.
,, uberrima, Vine.
,, gracilis, Reuss. Var. Reussii, Vine.
,, subelegans (d'Orb.) Pergens.
,, hunstantonensis, Vine.
,, var. ampliata, Vine.
,, Jessoni, Vine.
,, bohemica, Novák. Var.
,, Toucasiana, d'Orb.
,, ramosa, d'Orb., Hunst. & Yorksh.
,, dilatata, d'Orb. ,,
,, ,, cantabrigiensis, Vine.
Diastopora hunstantonensis. Vine.
,, ,, Var. A.
,, ,, Var. contracta, Seeley.
,, regularis, d'Orb.
,, fœcunda, Vine.
,, radians, Novák. Var.
,, papillosa ? Reuss.
,, Jessoni, Vine.
,, sulcata, Seeley.
Unitubigera papyracea, d'Orb.
Entalophora proboscidea ? Edw.

Ceriopora micropora, Goldf.
Reptomulticava collis, d'Orb.
,, simplex, d'Orb.
,, mamilla, Reuss.
,, favus, Seeley.
Zonopora irregularis, d'Orb.
,, variabilis, d'Orb.
Multicrescis variabilis, d'Orb.
Heteropora tenera, Hag.
Lichenopora collis, d Orb.

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§§ CHEILOSTOMATA, Busk.

Membranipora gaultina, Viue.
,, fragilis, d'Orb.
,, elliptica, Hag.
,, obliqua, d'Orb.
Hippothoa? simplex, d'Orb.

CORRIGENDA.—Further Notes on the Polyzoa of the Cambridge Greensand. Proc. Yorksh. Geol. and Polyt. Soc., vol. xi., pt. ii., pp. 250-275.

Page.	Line.	Please correct as follows:—
251	Note.	Ciply
252	24	*Delete* "I believe."
253	Note.	‡After 1881 insert "Geol. of Neighbourhood of Cambridge. G. W. H. Penning and A. J. Jukes-Browne: Mem. of Geol. Survey, 1881, pp. 149-154.
255	8	Etheridge.
253 & 260		read, A. J. Jukes-Browne.
262	11	neocomiensis.
,,	17	Sollas.
263	17-18	Stomatopora,
265	6	gracilis. 9 lines from top read *Radiolites.*
268	13	flabelliform.
269	2	Ostrea.
	4-5-10	congesta.
259	20	Dumerilii Aud. also p. 271, line 7.
274		8 lines from bottom read *débris.*

* ON THE LARGER BOULDERS OF FLAMBOROUGH HEAD AND OTHER PARTS OF THE YORKSHIRE COAST. PART IV.† BY G. W. LAMPLUGH.

My investigation of the boulders of Flamborough Head, begun in 1887, has now been continued on that part of the shore which lies between the South Sea Landing and the extremity of the headland.

I do not know of any other part of the Yorkshire Coast where erratic blocks are so numerous as they are on the beach for the last half-mile on the south side of the promontory. The total number within this space cannot be less than four thousand, and they lie so closely that for some distance it is possible to step from one to another.

Some are of large size (see examples in Appendix), and the average diameter is probably about two feet. They seem to have been derived chiefly from a coarse morainic gravel which partly fills a buried pre-glacial chalk valley in the adjoining cliff, but their retention and accumulation at this place is no doubt owing to its being sheltered from the heavy northerly gales which break with terrific force on the other side of the promontory, while here the sea rarely runs high enough to shift blocks so heavy as these.

I estimate that the total number of erratic blocks over one foot in diameter lying on the shore between South Sea Landing and the Lighthouse must exceed six thousand, and to this number about another thousand must be added if those are included which have been collected and heaped up to form a rude break-water at the South Landing. It would scarcely be profitable to catalogue so large a number as this even if it were possible, and I have therefore contented myself with examining eight hundred, chosen in different parts of the area, while of the rest I made a cursory survey which showed me that there is very little variation in the proportion of the various rocks among them, and therefore that, for

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*** An abstract of this paper was read at the Leeds meeting of the British Association.**

† See Proc. Yorksh. Geol. and Polytec. Soc., vol. ix., pt. iii., p. 339, for part i., and vol. xi., pt. ii., p. 231, for parts ii. and iii. of this paper.

purposes of comparison, the percentages yielded by the eight hundred might be safely accepted for the whole number.

My own classification of the rocks, being based only on an examination in the field, is rough and unsatisfactory where the igneous blocks are concerned. But fortunately, through the kind co-operation of Mr. A. Harker, it has been possible to add a detailed statement of the petrological characters of a selection of the most interesting boulders, with suggestive notes as to their probable origin. In most of these cases slices have been cut, and Mr. Harker has examined the specimens microscopically. The details of his work is printed separately at the end of this paper, and will, I think, be found the most exact and important contribution which has yet been made to the petrology of these erratics.

The composition of the eight hundred boulders is shown in the following table, the system of classification being that adopted in my former papers :—

TABLE 6.—800 BOULDERS ON THE SHORE BETWEEN SOUTH SEA LANDING AND THE EXTREMITY OF FLAMBOROUGH HEAD.

Boulders.		Per centum.
189	Carboniferous Limestone	= 23·6
166	Sandstone and Grit, probably nearly all Carboniferous*	= 20·8
4	Limestone, origin doubtful, probably Magnesian	= 0·5
12	Pebbly Quartzite and conglomerate (Palæozoic)	= 1·8
1	Coarse Breccia (Palæozoic)	
1	Clay-slate (Palæozoic)	
10	Liassic and nodular Limestone, (Secondary)	= 1·3
248	Fine-grained dark Basalt	= 43·7
81	Coarse-grained dark Basalt	
21	Grey doleritic Basalt	
22	Porphyritic Felstone, &c.	= 2·7
30	Granite, Syenite, &c., (including 4 of Shap Granite)	= 3·8
15	Gneiss and Mica-schist	= 1·8
800		100·3

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* My reasons for supposing the majority of the doubtful Sandstones to be Carboniferous are stated in Part i., *supra cit.*, p. 341.

In this, as in my previous Flamborough lists, the chief feature is the great scarcity of Secondary boulders of the requisite size, and the high proportion of blocks demonstrably from the Carboniferous system. It is necessary to point out, however, that though as a rule the drift here contains no chalk, yet in the morainic gravel already mentioned, and also in the lowest bed of boulder clay in one or two places, there are numerous partially-rounded blocks of hard chalk, evidently derived from the immediate neighbourhood, which, though they are truly boulders, cannot be distinguished on the shore from blocks derived directly from the solid chalk, and are therefore passed without record.

In reckoning the proportion of Carboniferous rocks, it must be remembered that, besides the Limestones and Sandstones, the greater portion of the Basalts also, which are usually the most numerous of all the boulders, have probably had their source in the sills and dykes of that system. Mr. Harker's microscopic examination has demonstrated that the "Whin Sill" in particular has been freely laid under contribution. With the Basalts added, the proportion of Carboniferous rocks rises to between 80 and 90 per cent. of the whole, a result which is sufficiently remarkable when we consider the distance of Flamborough Head from the nearest borders of the system.

The great relative abundance of the Basalts is obviously owing to the superior durability of this rock, and to the character of its jointage which favours the production of massive loose blocks.

In the last paper of this series I compared the Flamborough Head boulders with the erratics of the Holderness coast, as illustrated by a list of five hundred compiled on the beach near Withernsea. The comparison yielded many features of interest, and I have therefore continued this line of investigation, and have made similar lists at various places both north and south of the headland.

These lists are condensed in the following tables. It must be remembered that in each case I have reckoned only those boulders which are over one foot in diameter. My plan of working has been to start from a given point, and catalogue in order every erratic I could find which was of the requisite size, until a list of the desired length was obtained.

In the appendix will be found detailed notes of some of the Flamborough Head boulders which deserve especial notice either because of their large size or peculiar composition, or because their petrological character has been investigated by Mr. Harker and is described in his notes.

HORNSEA.

The following list was compiled in the cliffs of boulder-clay immediately north of Hornsea. This part of the coast is systematically overhauled by the collectors of "road metal," who even dig out the harder boulders from the cliff-face ; and I suspect that the excessive number of sandstones and the lowered proportion of the basalts in this as compared with the Withernsea list, may be owing to the selective agency of the cartmen.

TABLE 7.—100 BOULDERS IN THE CLIFF NORTH OF HORNSEA.

Per cent.	
17	Carboniferous Limestone
45	Sandstone and Grit ; probably mostly Carboniferous
18	Chalk (including one block of Red Chalk)
4	Jurassic Limestone and Septaria
10	Fine-grained Basalt
2	Coarse-grained Basalt
2	Porphyritic Felstone
2	Granite
100	

In this, as in the Withernsea list, the chief difference from the proportions which obtain at Flamborough is in the Secondary rocks. With regard to these, chalk boulders are far more numerous than at Tunstall (Withernsea), but this chalk seems rarely to have been derived from the Yorkshire beds, the flints in it being usually black or pink, and not gray.

The Septarian nodules are probably from the Kimeridge clay ; and other evidence of the extensive degradation of this formation is furnished by some of the gravels interstratified with the boulder clays in Holderness, in which flat fragments of the bituminous shale of the Upper Kimeridge are of frequent occurrence, often accompanied also by rolled fragments of Belemnites from the Speeton clay.

FILEY.

The next catalogue to which I shall draw attention carries us to the other, the northern, side of Flambro', and here also the proportion of the Secondary rocks is far higher than on the headland, but as the following lists will show, the composition of these Secondaries is altogether different from what it is in Holderness.

The list given below was compiled in the cliffs of boulder clay which overlie the Oolite near Filey Brigg. The boulders were chiefly in the lower boulder clay.

TABLE 8.—100 BOULDERS IN THE CLIFF ABOVE FILEY BRIGG.

Per cent.	
9	Carboniferous Limestone.
15	Sandstone, probably Carboniferous.
2	Magnesian Limestone.
2	Clay-slate (Palæozoic).
25	Sandstone, probably Jurassic.
26	Oolitic and Liassic Limestone.
19	Basaltic rocks.
2	Granite.
100	

The Secondary Limestones of this list consisted chiefly of blocks of the hard Coralline Oolite which in this locality forms the bed-rock for the drifts. The blocks may have been torn from the edge of the ridge when that extended, before the encroachment of the sea, for a few hundred yards further to the northward, and as the strata rise steadily in that direction the parent-rock was probably above the present level of the boulders.

I found recently on the rocky floor beneath the drifts at this place a most interesting feature, which so far as I know is not to be seen elsewhere on the Yorkshire coast. The oolitic platform is for some distance beautifully scored and polished by glacial striations; and from these markings we learn that the ice which scored the rock came from N. 20 E., in which direction there is now only the open sea.

CAYTON.

The next place at which I have counted the boulders is in Cayton Bay, four miles further north, where the drifts lie thickly in an ancient valley. The blocks examined were scattered over the face of the cliff, and had been chiefly derived from the lower clay.

TABLE 9.—100 BOULDERS IN THE CLIFF IN CAYTON BAY.

Per cent.	
14	Carboniferous Limestone.
25	Sandstone and Grit, probably mostly Carboniferous.
16	Jurassic Sandstone.
18	Liassic Limestone and Shale.
6	Oolitic Limestone.
18	Basaltic rocks.
3	Metamorphic rocks.
100	

In this instance although the drifts rest on Middle Oolites (Oxford Clay and Kelloway Rock) yet the Secondary Limestones have been mainly derived from the Lias ; and the list differs in this respect from that of Filey Brigg, though otherwise they present the same general features.

Among the hundred blocks examined it chanced that there was no granite, but granite is by no means absent, and would certainly have shown itself in a longer list.

ROBIN HOOD'S BAY.

My next station for examining the boulders was in Robin Hood's Bay. One hundred blocks were counted in the high cliffs of drift near the town, and a second hundred were afterwards examined on the beach, but though these latter yielded confirmatory results, there was so much uncertainty in distinguishing between true erratics and boulders of rock detached from the neighbouring cliffs that I have not considered it advisable to include them in the lists. These boulders were chiefly in the lower clay.

TABLE 10. 100 BOULDERS IN THE CLIFF NEAR ROBIN HOOD'S BAY.

Per cent.	
10	Carboniferous Limestone.
28	Sandstone, probably Carboniferous.
2	Limestone, probably Magnesian.
1	"Brockram"-conglomerate (Permian).
48	Jurassic Limestone, Sandstone, and Shale.
7	Basaltic rocks.
1	Porphyritic Felstone.
2	Granite (one from Shap Fell).
1	Gneiss.
100	

WHITBY.

The list which follows was compiled in the cliff at Upgang, near Whitby, about seven miles north of the last station.

Here once more we find that the drifts have accumulated to a great depth in a pre-glacial trough, and the coast is edged with high cliffs of boulder clay.

Two hundred boulders were catalogued, the greater number occurring in the lower Boulder-clay; and, as usual, the local rocks were almost entirely confined to this division.

TABLE 11.—200 BOULDERS IN THE CLIFF NEAR WHITBY.

		Per centum.
53	Carboniferous Limestone	= 26·5
36	Sandstone and Grit, probably Carboniferous ...	= 18·
6	Magnesian Limestone	= 3·5
1	"Brockram"-Conglomerate	
21	Sandstone; doubtful, but possibly Jurassic ...	= 10·5
50	Liassic Limestone, and Shale	= 25·
31	Basaltic rocks	= 15·5
1	Porphyritic Felstone	= 1.
1	Brecciated flinty rock	
200		100

The Secondary rocks in this table included numerous masses of the hard "Jet-rock" hale (Upper Lias), besides fragments of Middle and Lower Lias limestone. Magnesian Limestone is decidedly more plentiful in the drift of this locality than further south, but usually in fragments too small to pass into my list. As in Table No. 9, true granites chance to be absent though by no means rare in the locality. The curious flinty rock recorded last in the list is of a type rare in our drifts. It has been examined by Mr. Harker, and further particulars respecting it are given in Mr. Harker's notes.

Summary and Notes.

Combining, now, for the purposes of comparison, all the above records and also those given in the previous parts of my paper, it will be found that the whole may be condensed into a table which will show at a glance the proportion of the various rocks at the different localities, as follows :—

Table 12. COMPARATIVE SUMMARY OF THE FOREGOING LISTS.

Boulders over 1 foot in diameter. Origin.	South Holderness, near Withernsea. 500 boulders on the beach.	North Holderness, near Hornsea. 100 boulders in the cliff.	Flamborough Head, South Side. 1100 boulders chiefly on the beach.	Filey, near the Brigg. 100 boulders in the cliff.	Cayton Bay, South Side. 100 boulders in the cliff.	Robin Hood's Bay. 100 boulders in the cliff.	Whitby, North of Upgang. 200 boulders in the cliff.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Carboniferous Limestone (including also a few other Palæozoic Sedimentary Rocks)	22·8	17·	23·3	13·	14·	13·	30·
Sandstones, Grit, Conglomerate, &c. (probably all, or nearly all, from Carboniferous or other Palæozoic Rocks)	14·4	45·	26·8	15·	25·	28.	18·
Mesozoic Rocks (Jurassic Limestones and Sandstones, Chalk, &c.)	22·1	22·	1·	51·	40·	48·	35·5
Basaltic and other Eruptive Rocks	37·3	14·	43·2	19·	18·	7·	15·5
Granite, Schist, Gneiss, &c. ..	3·4	2·	5·7	2·	3·	4·	1·
Total ...	100·	100·	100·	100·	100·	100·	100·

This summary shows that in spite of local differences there is a fundamental agreement among the lists.

The proportion of far-travelled igneous and metamorphic rocks remains always low, its maximum barely exceeding 5 per cent., and yet it is a quantity which is never absent.

Respecting these rocks, Mr. Harker's notes indicate that no inconsiderable number of those found at Flamborough (and presumably, therefore, elsewhere also) may have come from Scandinavia, while others have been furnished by the northern and eastern parts of the English Lake district, and others again by the Cheviot Hills and the southern part of Scotland.

The proportion of blocks from the Carboniferous system is, on the other hand, always high. And when, in addition to the rocks which can be recognized at a glance as Carboniferous, the basalts from the same system are considered, the proportion from that system in almost every case outnumbers, and generally greatly outnumbers, all the other rocks combined.

With the definite and well-known trail of the Shap granite and Brockram erratics to guide us, we need feel no uncertainty as to the quarter whence these Carboniferous rocks have been derived. It is clearly the elevated region lying to the north-westward, eighty or a hundred miles away, which has been the main contributor, and the route must in most, if not in all cases, have been down Teesdale, and thence south-eastward along the coast.

It is the Secondary rocks which form the unstable factor of the lists, both in proportion and in composition. In fact, were these Secondaries eliminated, the other differences would become very slight indeed. From the distribution of these rocks we gather the same lesson as from the study of the route taken by the Carboniferous rocks, that the Eastern Moorlands and the Wolds were not entirely overridden by the great ice-sheet, but that they formed a buttress upon which that mighty stream impinged.

The striking low percentage of Secondary rocks on Flamborough Head demands explanation ; though perhaps, as already remarked, this inequality may be somewhat exaggerated in my tables by the omission of a few loose blocks of chalk. But when the general character of the ice-movement from the seaward is taken into consideration, in conjunction with the fact of the considerable eastward protrusion of the promontory, the peculiarity is readily explicable. However as I have a paper in preparation wherein the drifts of the headland are to be fully described, it will perhaps be more convenient to defer for the present further discussion of the theoretical bearing of the facts now recorded.

With regard to the question as to how far these larger boulders are reliable as guides to the origin and proportion of the stones in the drift, I gave in a former paper[*] my reasons for preferring them to the smaller pebbles as evidence of ice-movement. I have however commenced an investigation, complementary to the present work, of the smaller pebbles only, and hope at some future time to make known the result. So far as I have gone the proportions of the smaller pebbles agree more closely with those of the larger boulders than I had expected, the chief difference being that hard crystalline rocks, especially vein-quartz, are more abundant among the pebbles.

APPENDIX TO PART IV.

SOME OF THE MORE IMPORTANT BOULDERS BETWEEN SOUTH SEA LANDING AND HIGH STACKS, FLAMBOROUGH.

*The prefixed number indicates the ordinal position of the boulder in the original full list. All dimensions are in inches. The sign + indicates that it has been impossible to obtain the full measurement. The asterisk * denotes that there is a petrological description of the boulder in Mr. Harker's notes.*

No.

*1. *Position:* On the beach near Old Falls. *Description:* Fine-grained Basalt. *Size and shape:* Oblong, flat sides. 54 × 36 × 30 inches.

*15. Opposite Limekiln. Coarse greenish Dolerite. Oval, rounded. 14 × 8 × 4 inches.

*21. Near same place. Porphyritic Dolerite or "Augite-porphyrite."[*] Size and shape similar to No. 15.

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[*] Proc. Yorksh. Geol. and Polyt. Soc., vol. xi., pl. iv.. p. 233.

[*] These terms are taken from Mr. Harker's notes.

*25. Fifteen yards east of No. 1. Grey Saussurite-gabbro. Flattish disc. 18 × 14 × 8 inches.

*33. Near same place. Black Hornblende-biotite, gneiss. Oval. 28 × 14 × 9 inches.

47. On the "Scaurs," among the seaweed near Old Falls. Fine-grained Basalt. Rude cube. 44 × 40 × 28 inches.

*54. Just beyond Old Falls. "Whin-sill of Teesdale" (Dolerite). Angular slab. 38 × 26 × 6 inches.

*114. Opposite "Windlass." Biotite-granite. Globular, sea worn. About 18 inches diameter.

127. Near last. Whin-sill, in the moving beach. 18 × 8 × 6 inches.

*134. Slightly east of "Windlass." Porphyrite, with pink crystals. Rudely oblong. 30 × 24 × 24 inches.

*146. Near same place. Dark dolerite, much decomposed. Rhomboid : subangular. 24 × 18 × 18 inches.

*158. Further east. Coarse Biotite-granite. Oval. 30 × 24 × — inches.

*167. Close to 158. "Whin-sill." Rectangular slab. 14 × 6 × 4 inches.

*174. Between Windlass and Cattlemere, twenty yards from the cliff. Andesitic-lava. Rounded oblong. 18 × 14 × 10 inches.

*202. West of Cattlemere, near the cliff. Andesitic-lava. Shape and size similar to No. 174.

*214. Near same place. Whin-sill (greyish Dolerite). Subangular cube. 15 × 14 × 9 inches.

*240. Further east, near the cliff. Olivine-basalt. Oval. 24 × 12 × — inches.

*253. Near No. 240. Greyish Granite. Subangular cube. 24 × 18 × 12 inches.

*503. In Green Stacks Bay, close to the cliff. Grey Whin-sill. Globular. 24 × 24 × — inches.

*508. Middle of Green Stacks. Coarse brecciated Felspathic grit. Rhomboidal ; subangular. 44 × 42 × 22 inches.

*516. } 517. } South side of Green Stacks. Two large masses of fine-grained Grey Granite, probably originally one block. 36 × 30 × 20 and 40 × 38 × 24 inches.

*524. South corner of Green Stacks. Whin-sill. Rhomb. 26 × 24 × — inches.

*543. Middle of High Stacks Bay. Augite-syenite. Small globular boulder. About 16 inches diameter.

*545. Near high-water mark in recess west of High Stacks. Whin-sill. Irregular rhomb. 24 × 18 × 18 inches.

*547. Close to No. 544. Reddish gneiss, with much knotted quartz. Irregular oval with flat side. 30 × 24 × 12 inches.

*562. In second recess west of High Stacks. Black Dolerite. Pear-shaped mass. 28 × 24 × 12 inches.

The above-mentioned erratics were included in the eight hundred boulders catalogued, and chips from them were submitted to Mr. Harker for microscopic examination. Those which follow have been selected from among the boulders not catalogued because of their large size, and as they have no ordinal position in my list I have prefixed a distinguishing letter instead of a number.

A. At the headland east of South Sea Landing. Greyish gneiss. Rounded, oval. About 60 × 36 × 30 inches.

B. At half-tide level east of Old Falls. Mountain limestone. Rectangular cube. 65 × 48 × 40 inches.

C. In Cattlemere, near the cliff. Greyish Hornblende-schist (?) with black slaty inclusions. Triangular. 48 × 30 × 24 inches.

D. At half-tide, east of Cattlemere. Mountain limestone. Rectangular. 60 × 36 × 20 inches.

E. Near the "Matron" Pinnacle. Shap-granite. Irregular oval. 48 × 40 × 40 inches.

F. Near same place. Coarse pink granitic rock (*not* Shap). Globular. 40 × 38 × 24 inches.

G. Near Matron. Mountain limestone. Rectangular. 90 × 50 × 40 inches.

H. Close by last. Mountain limestone. Rectangular. 36 × 42 × 24 inches.

PETROLOGICAL NOTES ON SOME OF THE LARGER BOULDERS ON THE BEACH SOUTH OF FLAMBOROUGH HEAD. BY ALFRED HARKER, M.A., F.G.S.

In undertaking to examine the rocks chosen by Mr. Lamplugh from his large collection of boulders, my desire was not so much to form a general opinion on the question of their probable sources, as to identify, among the numerous boulders, a few of which the original localities could be fixed with certainty. This hope has been to a great extent frustrated by the discovery that a large proportion of those igneous boulders which I examined, have, in all probability, been brought from Norway.

The bulk of the specimens selected and submitted to me consist of granitic, gneissic, and other crystalline rocks, such as might have been derived, so far as their individual characters are concerned, either from Scandinavia or from the Scottish Highlands. Among them are some undoubted Norwegian rocks, while none can be pointed out as *certainly* brought from Scotland. It may well be, then, that the whole of the doubtful rocks are also of Norwegian origin, and this is rendered probable by other evidence as to the movements of the ice and the consequent directions of transport. Such rocks, however, in endless variety, cover the greater part of Norway, and although many of them have been described by Möhl, Brögger, Reusch, and others, our data are far from sufficient for our purpose.

Nevertheless, I propose to note the characters of one or two rocks which can be referred, without hesitation, to Norwegian localities, and a few specimens illustrating the varied characters of the rest, besides some boulders which can be identified as of British origin.

In addition to Mr. Lamplugh's numbers, I give in brackets [ ] references to slides in the cabinet of the Woodwardian Museum. A few of these were prepared from specimens collected before Mr. Lamplugh's systematic examination of the ground was undertaken, and for these I am not able to give the corresponding numbers in his catalogue.

In some former notes I described specimens of boulders from the Basement Clay at Bridlington Quay and Dimlington, which I referred to the augite-syenites of the neighbourhood of Christiania (vol. xi., pp. 303, 304). Further examination and comparison with specimens from Frederiksvaarn, &c., [1091, 1133] leaves no doubt of the correctness of this determination. Since that time Mr. J. W. Stather has given me another specimen from Dimlington, which, though rather darker in aspect, agrees closely with the former, showing the same rather coarsely crystalline aggregate of felspars and pyroxene with some flakes of lustrous brown mica. Under the microscope [1065] this rock shows a close resemblance to [936], already noticed. The large crystal-plates of felspar show no plagioclase lamellation, and only a very delicate cross-hatched structure when viewed between crossed Nicols. The augite shows a diallagic "schiller"-structure only inconstantly, and chiefly in the interior of the crystals. A deep brown mica is present, as before, often in close association with imperfect crystals of magnetite, while apatite prisms are enclosed by all the other constituents.

Among Mr. Lamplugh's specimens is one, No. 543, from the middle of High Stacks, of a moderately coarsely crystalline rock showing large grey felspars, black pyroxene, and a golden-brown mica. A slice of this [1139] shows characters very similar to those of the preceding. The felspar, in broad, irregular crystal-plates, is almost entirely orthoclase, with no microcline-structure, but it has minute opaque rod-like interpositions disposed in parallel lines. The pale-green augite has similar enclosures, sometimes densely grouped and in two sets of intersecting lines. Magnetite is rather plentiful. The brown mica is either associated with this, or intergrown with the margins of the augite, or in minute flakes within the felspar crystals. These crystals also enclose minute apatite needles, often with parallel arrangement, and larger apatite prisms occur here and there in the rock.

Although two types of Norwegian augite-syenites can be recognised in the East Yorkshire boulders, we have not yet identified any specimen of the associated elæolite-syenites from the same source.

Another Norwegian type of rock represented in our collection is that of the so-called "saussurite-gabbros." A boulder some distance south of High Stacks shows a rather coarsely crystalline admixture of a green fibrous amphibole with a dull white felspathic substance.

Micro. [1054] The slice shows at once that we are dealing with a gabbro in which the pyroxene has completely passed over into a fibrous amphibole of the kind known as uralite. This gives a pale green tint, sometimes almost colourless. Vibrations nearly parallel to the fibres give a bluish green, those transverse a paler and yellower green. A rather wavy fibrous structure is common, but some of the cross-sections show the proper prismatic cleavage of hornblende. Most of the felspar is converted into a clotted, opaque product with abundant secondary quartz; but the few scraps which remain undestroyed show fine twin-lamellation with moderate extinction-angles, and are probably labradorite.

This rock seems to be identical with some of the "saussurite-gabbros," which have been described from south-western Norway, and occur also in the north. There need be no hesitation in referring the boulder to that country as its source.

No. 25 is, with little doubt, another variety of the same group of rocks. It is a medium-grained crystalline rock, showing plenty of dark-green hornblendes set in a light-coloured felspathic substance, evidently much altered.

Micro. [1049] The hornblende is in section very pale to almost colourless. Cross-sections exhibit the usual prismatic cleavage-traces, and some of the crystals are twinned on the usual law. From the general character of the mineral and the manner in which the irregular crystal plates penetrate one another, besides the nature of the rock as a whole, this hornblende seems to be almost certainly the result of alteration of the pyroxene in a rock of the gabbro family. Outlines of felspar prisms are occasionally detected, but there has been extensive decomposition, and much of the rock consists of secondary minerals, especially epidote grains and calcite, with some quartz. There is a fibrous, colourless hornblende, usually fringing the larger crystals of the same, but also occurring in matted patches, and clearly of secondary origin. Besides these, there are little prisms with high refractive index, weak double refraction, straight extinction, and longitudinal cleavage-traces, which must be referred to zoisite. All these appearances are such as are found in the "saussurite-gabbros."

Of the numerous examples of gneissic rocks, only two or three have been specially noticed, since these do not offer much hope of precise determination of their sources. No. 33 is a dark, fine-grained rock, which shows abundant little glistening flakes of mica, arranged parallel to a definite plane, while a lens enables us to detect in addition some black hornblende. The rock is a hornblende-biotite-gneiss of fine texture.

Micro. [1051] The slice has a fresh appearance, showing little flakes of brown biotite and green hornblende, set in a clear, finely-crystalline ground. As in many other metamorphic rocks, this granular ground-mass is clear enough for quartz; but on closer examination many of the grains show twinning and even twin-lamellation, and there can be no doubt that much of the mass is of felspar. Some more or less clear patches, with rather granular structure, seem to represent felspar crystals, porphyritic in the original rock, but now completely replaced. Ragged crystal-grains of magnetite must, from their manner of association with the coloured mineral, be also secondary. The rock presents an extremely close resemblance to some of the highly metamorphosed volcanic agglomerates in contact with the Shap granite in Westmorland, and this is the nearest possible locality for its origin; but we cannot exclude the possibility of the rock being a dynamo-metamorphic product and having its home in Norway.

A large boulder from south of High Stacks is a typical hornblende-gneiss, showing white felspathic and dark hornblendic bands, half-an-inch or more in thickness.

Micro. [1053] The parallel structure is not apparent in the slice. Zircon and apatite occur as the earliest-formed minerals. The hornblende is deeply coloured and highly pleochroic, giving colours varying from intense green, almost opaque, to a rather yellowish brown. The felspar is mostly decomposed, but appears to have been orthoclase. The quartz is partly interstitial, but largely in the form of rounded grains enclosed in the hornblende. It shows the "strain-shadows" indicative of mechanical forces.

No. 547, taken near the Matron, High Stacks, at high-water mark, is a gneiss of different type and finer texture. It has no hornblende, but only biotite, which, besides an ill-defined parallel arrangement, has a tendency to collect in clusters, which show as dark depressions on a water-worn weathered surface. The pink felspar of this rock seems to be orthoclase. The quartz is mostly confined to lenticular streaks following the general gneissic structure of the rock. No. 43 is a grey gneiss of similar characters.

Rocks such as these last three must have been transported from some great metamorphic region of gneisses and crystalline schists; in this case almost certain from Norway. Some of the granitic rocks, though not properly gneisses, also give evidence of dynamo-metamorphic action.

Of the many granitic rocks, mostly biotite-granites, found among our Flamborough boulders, few, except the Shap granite, can be certainly set down as British, and the majority are in all probability derived from Scandinavian localities. A grey biotite-granite from Mr. Lamplugh's collection, No. 114, exhibits no very marked characters. Under the microscope [1150] it shows crystals of brown, pleochroic sphene, little prisms of zircon, and octahedra of magnetite. The brown mica has the usual characters; the turbid felspars are a striated acid plagioclase, with subordinate orthoclase, and occasional veining of the one by the other; while the quartz is mostly interstitial, but with a tendency to form mosaic-like patches.

This rock, excepting a slight bending of the mica-flakes and perhaps the veined character of some of the felspars, has, it is true, little suggestive of mechanical stress, but other examples are more instructive. No. 516 is a grey biotite-granite of fine grain, but containing some pinkish felspars up to an inch in length.

Micro. [1140] This specimen has no sphene, but little acicular crystals of zircon and apatite, with octahedra of magnetite, occur enclosed by the other constituents. The intensely pleochroic brown mica has a slightly oblique extinction, which is sufficient to show in many flakes a twinning parallel to the basal plane. The felspar and quartz build irregular interlocking plates, and a portion of the latter mineral is often enclosed within the former in numerous rounded grains. Sometimes a number of these little quartz-grains within the same felspar crystal have the same optical orientation; and elsewhere we find in the heart of a felspar plate a little round patch of delicately branching micropegmatite. The felspar itself shows minute but rather shadowy twin-striation. The cross-striation characteristic of microcline is very general, but is sometimes confined to a portion of a crystal, usually the interior. The clear quartz has traces of minute fluid-pores, usually without bubbles. It invariably shows between crossed Nicols the strong "strain-shadows" or "spectral polarisation" indicative of mechanical forces.

No. 253 is a very fine-grained grey granite, rather weathered. No. 158, of rather coarse grain, shows lustrous black mica, pink felspar, and greyish glassy quartz, and in a hand-specimen looks very like the rocks described in my former notes [942, 943]. The only other granitic rock sliced is from a boulder near the headland east of South Sea Landing, and is a biotite-granite of moderately coarse grain. The pink felspars are often in good crystals with Carlsbad twinning; the dark mica tends to aggregate in little nests or patches; the irregular quartz-grains are grey to reddish in colour.

Micro. [1047] Though the hand-specimen has no gneissic character, a slice shows under the microscope decisive evidences of crushing. The mica is often bent or buckled along "gliding-planes," and many flakes are torn to pieces. This mineral is mostly altered into a bright green, dichroic, and fairly birefringent substance agreeing with chlorite, and flakes cut nearly parallel to the basal cleavage exhibit many minute rutile-needles arranged parallel to three directions at angles of 60° to one another. The felspars are mostly microcline and microperthite, with a finely striated acid plagioclase. Of these the microline is, as usual, of later formation than the quartz of the rock. The last-named mineral builds clear grains, which between crossed Nicols give a somewhat indistinct extinction ("strain-shadows"). Other features in the slice pointing to the effects of crushing are an occasional veined and "cataclastic" structure, and the occurrence of little flakes of secondary white mica in the heart of the felspar crystals.

Quartz-porphyries of various kinds are rather abundantly met with among our boulders, though much less common than the gnessic and granitoid rocks. Most of them can be matched among the minor acid intrusions (chiefly dykes) so frequent in the English Lake District, but it would be rash to put them down as coming from that region, the petrological characters of these rocks not being sufficiently distinctive. We can only say that their *nearest possible* home is among the Silurian rocks of Westmorland. A specimen taken about half-way between High Stacks and South Sea Landing shows a flinty-looking, dark brown ground, with pink patches, enclosing little lath-shaped sections of glassy felspar and clear grains of quartz.

Micro. [1055]. This is the rhyolitic type of quartz-porphyry, showing the uniformly cryptocrystalline ("microfelsitic") ground-mass which some petrologists would regard as indicating a devitrified glassy rock, though the specimen shows no conclusive evidence of an originally vitreous condition. The imbedded quartz-grains are rounded, and penetrated by little inlets of the ground-mass, owing to corrosion of the crystals by the liquid magma. The felspars, both orthoclase and acid plagioclase, are considerably decomposed, and secondary patches of greenish material in the rock, crowded with granules of magnetite, may represent destroyed augite.

A small boulder. from the beach at Hornsea, is, to the eye, not unlike the preceding, but the ground-mass is more decidedly crystalline [944]. Quartz, orthoclase, finely striated plagioclase, and apparent relics of augite crystals are present as before, the felspars often giving rise to secondary epidote. A few slender prisms of apatite are seen in addition.

No. 508, from the beach at Green Stacks, is a very remarkable rock. Pinkish-white felspar crystals and smaller crystal-grains of quartz are prominent in the specimen, but their rounded outlines and the manner of their occurrence sufficiently prove their fragmental origin, and some of the larger fragments appear to be subangular pieces of composite rocks. The ground of the specimen, though studded with minute crystal-facets, is essentially a dull, compact matrix, varying from pale-green to purplish-brown.

Micro. [1141]. The slide shows felspars of various kinds to be the most abundant constituents. Some are deeply altered, with numerous secondary products; others have the limpid appearance usually seen in the re-crystallised felspars of highly metamorphosed rocks. Some crystals have fine twin-lamellation on the albite type, occasionally crossed by a second set of lamellæ (the pericline twinning); others, without twin-lamellation, show between crossed Nicols a finely veined structure. Fissures in the crystals are sometimes occupied by veins of crystalline calcite; elsewhere granular, brilliantly polarising epidote occurs, often in strings following the twin-lamellæ, which are known to correspond to planes of chemical weakness, but also usurping, together with quartz, the whole of an area formerly filled by felspar. Granules of epidote and patches of well-cleaved crystalline calcite occur in the general ground of the rock, besides grains of iron-oxide, and a pale-green dichroic mineral of the chlorite family in bent flakes, giving rather low polarisation-tints. What appears to be a single rounded grain of quartz is sometimes found, when examined in polarised light, to consist of a crystalline mosaic of clear, irregularly-shaped grains, and similar indications of recrystallisation are seen in some of the felspars.

The rock may be regarded, then, as a very felspathic grit, almost an arkose, highly metamorphosed. The only possible *English* source is the alteration-zone around the Shap Fell granite, where somewhat similar rocks occur. I can find no account of such a type in Scandinavia, but it might probably be matched among the various metamorphosed grits of the central Scottish Highlands, if we admit the possibility of rocks being transported from that region to our coast. It is *a priori* probable that the well-known Shap granite boulders should be accompanied by specimens of the altered rocks, at least equally durable, which surround the granite outcrop, and I have already suggested such an origin for another of the Flamborough boulders.

I pass on to a specimen from the beach east of South Sea Landing. This is one of the so-called "porphyrites," and closer examination shows it to be a partly decomposed hypersthene-andesite. It has a brick-red ground-mass enclosing striated felspar prisms up to one-tenth of an inch in length, patches of dark mica to a quarter of an inch, and confused dark spots.

Micro. [1056]. The porphyritic felspars, when sufficiently clear, show fine twin-lamellation and extinction-angles proper to labradorite. There are roughly rectangular sections of a fibrous, green, pleochroic substance, with indistinct polarisation and straight extinction, doubtless bastite pseudomorphs after hypersthene. Some paler green and more amorphous patches are derived from augite, of which a few unaltered granules have sometimes survived. This mineral was subordinate in quantity to the rhombic pyroxene. Biotite flakes, also considerably altered, are occasionally seen, and little grains of magnetite are fairly abundant. The ground-mass seems to have consisted largely of felspars, but is deeply decomposed, and stained reddish-brown by ferric oxide, which has also coloured the borders of some of the porphyritic felspar-crystals. Hypersthene-bearing rocks similar to this occur in place in the Cheviots.

The next two specimens, Nos. 174 and 202, also belong to the type usually described as porphyrites. They show a dull compact-looking ground of a dark purplish-brown colour, enclosing glassy felspars one-tenth to one-quarter of an inch long, or sometimes larger, and little brown pseudomorphs. The rocks are evidently andesitic lavas.

Micro. [1147, 1148]. The large felspars, which are quite fresh, show lamellar twinning on the albite law, often interrupted and in many cases terminating abruptly at a crack in the crystal. There are well-marked zones of growth, besides a more irregular patchy appearance. The ground-mass is composed mainly of small closely-lamellated felspars, which have an elongated form and the parallel arrangement due to flow. This ground, however, is packed with opaque matter, part of which shows forms indicating octahedra of magnetite, while the bulk of it is red-brown by reflected light and consists of ferric oxide. One or two rounded crystals of pale augite are seen, and some pale-green decomposition-product may also represent a pyroxenic mineral. Calcite is another secondary product, and often occupies patches which seem to be vesicles. The pseudomorphs already referred to are surrounded by a black border and traversed by irregular cracks. They are sensibly pleochroic. Some show a well-marked cleavage, and when this is seen, the crystals extinguish parallel to the cleavage-traces, and give the deepest absorption for vibrations in that direction. They may be due to the alteration of biotite, of which one or two fresh flakes are present, but whether they consist of allanite or some other uncommon mineral I am not able to state with confidence.

No. 134 (not sliced) is a similar rock, though with a rather more generally crystalline appearance and with fewer porphyritic felspars. It has a general brown colour, and is penetrated by little red veins of ferric oxide, presenting altogether a close resemblance to some of the "porphyrites" of the Cheviots, which have certainly supplied numerous boulders to our east coast. It must be remembered, however, that lavas of a not dissimilar type are extensively developed in the Old Red Sandstone and Carboniferous of southern Scotland, and such specimens as Nos. 174 and 202 cannot be confidently traced to their source until these rocks are very thoroughly known.

I select next a few samples from the very numerous dolerites and diabases, which for the most part present few distinctive features in hand-specimens, while even under the microscope they only occasionally show sufficiently marked characteristics to be safely identified with known rocks. No. 15 has a dull, dark-grey groundmass, enclosing yellowish-white felspars up to a quarter or half an inch long, with evident twin-striation, and little black spots of a pyroxenic mineral.

Micro. [1052]. The porphyritic felspars show Carlsbad, albite, and pericline twinning, and some degree of zonary banding. The pyroxene is found to be of a rhombic kind, a green pleochroic hypersthene, with a rather unusual mode of alteration. It is very abundant, and little octahedra of magnetite also occur in some quantity. The rest of the rock consists of little lath-shaped, striated felspars, with partial fluidal arrangement.

Another specimen, No. 562, from near the Matron, shows to the eye very similar characters. Many of the felspars have a rounded outline, and this, with the other characters of the rocks, recalls the peculiar lavas of Eycott Hill, in Cumberland. The resemblance is indeed very marked, and there would be no improbability in the transportation of boulders from Eycott to Flamborough: the granophyre ("syenite") of the neighbouring Carrock Fell has long been known among the Holderness boulders.

No. 146 must also be placed here It shows the same yellowish, striated felspars, rectangular or rounded in outline, imbedded in a dark fine-grained matrix, and is precisely like specimens collected from the great porphyritic lava of Eycott Hill. The slice [1149] is very like [1052], although the yellowish-brown pseudomorphs, which seem to represent vanished hypersthene, show less distinctive characters. As before, the ground-mass consists of very numerous little striated felspars, with abundant magnetite and decomposition-products of pyroxene.

The next specimen, No. 21, shows a dark ground-mass of very fine texture, enclosing greenish decomposed felspar-crystals and smaller crystals of black augite. It is indeed a porphyritic dolerite and would be named "augite-porphyrite" by some continental geologists.

Micro. [1048]. The porphyritic augites are perfectly idiomorphic and almost colourless in the slice. The larger porphyritic crystals, belonging presumably to a basic felspar, are completely pseudomorphed by calcite with strings of a green chloritoid mineral. The crowded felspars of the ground-mass are lath-shaped, with twin-striation, and seem to be of labradorite or some near variety. They have a pronounced arrangement in lines of flow sweeping past the porphyritic crystals, though a few of them are included by the larger augites. The remainder of the ground consists of little sub-ophitic grains of augite, with greenish and other decomposition-products. The slide shows plenty of magnetite, most of which is evidently secondary.

No rock of this kind occurs *in situ* in the North of England, unless it be one of the comparatively little known though extensive lavas of the Lake District. On this point it would be rash to pronounce. Probably a more thorough acquaintance with the volcanic series of Cumberland and Westmorland would enable us to detect them in some abundance among the boulders of East Yorkshire.

The next specimen, No. 54, has a mottled black and light-grey appearance, due to the admixture of augite and felspar. Under the microscope [1050] the bulk of the rock is seen to consist of these two minerals. The augite is very pale in section : it occurs in twinned crystals, and, in addition to the usual prismatic cleavage, has a very delicate striated structure. There are also some fibrous dirty-green pseudomorphs after a rhombic pyroxene. A few flakes of brown mica occur, besides irregular crystal-grains of magnetite, and rarely one or two needles of apatite. The felspar is chiefly in little elongated twinned crystals, with a few larger ones, and a zonary shading is often seen in polarised light. A little quartz, occurring interstitially, is the latest product of consolidation in the rock. There is no doubt that we have here a specimen of the Whin Sill of Teesdale, described by Mr. Teall. Our rock agrees identically with specimens taken at High Force [378, 379].

No. 167 is a rock of slightly coarser grain, the ophitic arrangement of part of the pyroxene being easily seen. Its microscopic structure is of the diabasic rather than the true doleritic type [1142], the division of the felspar into two generations not being very marked, though there are a few rather clear shapeless felspars of late formation and with zonary banding. The rock is considerably decomposed, but retains evidence of having contained both monoclinic and rhombic pyroxenes. As before, there is clear quartz, some of which seems to be original ; and scattered needles of apatite occur in places in the slice. This is a specimen of the coarser variety of the Whin Sill, and is no doubt from Teesdale, the outcrops to the west of the Penines being of a finer-grained variety.

A boulder between High Stacks and South Sea is another example of the coarser type of Whin Sill from Teesdale, and, as is often the case, shows a little dark mica as well as augite. The rock is considerably decomposed, and contains specks of iron pyrites. Its microscopical characters [1058] do not need detailed description, since they agree generally with the foregoing. The augite here is yellowish-brown in section, and usually twinned ; it shows the basal striation already mentioned very markedly.

Another sliced specimen [1057] is a fine-grained doleritic variety, doubtless from the same source, though the remains of rhombic pyroxene are less plentiful. This example is fresher, and shows very beautifully the zonary banding of the felspars and the characters and mutual relations of all the constituents. No. 127 is very similar, but the slice [1146] shows a little brown hornblende, doubtless original, associated with the augite, another character met with in the Whin Sill, as described by Mr. Teall. Some other rather compact doleritic rocks in our collection [1062, 1063] have a considerable quantity of brown hornblende : these, from their general appearance in thin sections, may be also Whin Sill boulders, but the specimens are scarcely characteristic enough to decide the point.

Many of the dolerites have suffered much from weathering, and lost some of their most characteristic features. A specimen taken between High Stacks and South Sea Landing [1060] shows good zoned felspars, mostly once twinned. These and the quartz (probably secondary) are crowded with needles of apatite. The pyroxene is in great measure destroyed. No. 545 [1145] has the felspars much decomposed and without any zonary banding. Its other characters are like those of the preceding, except that the augite shows very clearly the basal striation already noticed as a special feature of the Whin Sill. This is very clearly exhibited also in Nos. 503 and 524 [1143, 1144], two moderately coarse-grained dolerites with a second generation of felspars, shapeless and strongly zoned. The former has relics of a rhombic pyroxene, beside the twinned and striated augite. These rocks agree very fairly with some specimens of the Whin Sill of Teesdale. No. 214 is a similar-looking rock, and the boulders about Flamborough include many examples of rather coarse-grained dolerites, often with specks of iron pyrites, which must be for the most part derived from the outcrops of Teesdale.

Olivine-bearing dolerites and basalts are much less abundant. No. 240 is a dark compact fresh-looking rock. enclosing porphyritic black augites, up to a third of an inch long, and rounded crystal-grains of yellow-green olivine. This can scarcely be a North of England rock, but could no doubt be matched in Southern Scotland. An olivine-basalt from the Basement Clay of Flamborough was described in my former notes [933]. I have not been successful in identifying among our boulders any of the well-known dyke-rocks of Durham and Northumberland, though it is quite possible that such might occur.

Mr. Lamplugh has forwarded me a specimen from a remarkable boulder (12 inches × 8 × 4) in the Lower Boulder-Clay of Upgang, near Whitby. It has the appearance of a brecciated flint, the vein-like spaces dividing it being marked either by opaque matter or by a curious pink colour; but in the yellow-grey flinty mass itself are seen numerous little globules recalling a spherulitic structure. A slice [1253] shows that the original substance, perhaps a rhyolitic lava, has been replaced by more or less distinctly crystalline silica with a patchy arrangement; while the little globular bodies show a radial structure, which gives a good "black cross." The whole reminds one closely of the micro-structure of some so-called "moss-agates."

In the foregoing notes I have endeavoured to abstain from any speculations not directly prompted by the specimens. The only definite results arrived at may be briefly summarised here: (i.) Among the boulders examined are some certainly from the south and west of Norway; (ii.) most of the granitic, gneissic, and crystalline schistose rocks are referred with probability to the same source; (iii.) other boulders have been furnished by the northern and eastern parts of the English Lake District; (iv.) others have been derived from Teesdale; and (v.) others again have come from the Cheviot Hills and the southern part of Scotland.

In conclusion, I should like to call attention to a feature which I have noticed in one or two specimens of limestone boulders, and which may be found to be of more frequent occurrence. It is well exhibited by a small sub-angular boulder of dark crinoidal limestone, doubtless Carboniferous, from the clay nearly below Flamborough Lighthouse. The specimen is three-and-a-half inches long, and is scratched in at least three directions. Its surface shows three or four rather angular depressions or shallow pits, which are polished like the rest of the stone, but have only a few scratches. There can be little doubt that this is an example of the "impressed limestone pebbles" noticed by Dr. Sorby and others; the little pits, which are nearly an inch across, being due to the dissolving away of the carbonate of lime under pressure from the angles of neighbouring pebbles. The specimen, as found, was not in contact with any other boulders, and it is a matter of speculation at what stage in the history of the boulder it was subjected to the pressure in question. The fracture of boulders is well-known in some districts, and has been recorded by various German geologists*, but the solution of a limestone boulder, being presumably a slow progress, would appear to present a different problem.

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* *Of* Van Calker, Zeits. Deutsch. Geol. Ges., vol. xli., p. 343 (1889).

NOTES ON BORINGS FOR WATER AND SALT IN THE COUNTY OF YORK.

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We are often told that the geology of England affords an epitome of that of Europe, and it is certainly equally true that an epitome of the geology of England may be found in the County of York.

Its wide diversity of strata, and difference of elevation and condition has a direct relation to its remarkable county boundary, which includes in an area of artificial limits, portions of river-basins draining into the eastern and western seas.

The county includes the northern and central groups of the rivers, making up the Humber basin, but the southern group of the streams of that basin are beyond its boundaries, while westward, where the Pennine Chain forms the Humber watershead, the West Riding of York overlaps the Pennine axis and occupies no less than 400 square miles of country draining into the Ribble, Lune, and Eden, the latter draining into the Mallerstang valley, should be considered as belonging naturally to the Cumberland rivers, while the two former should be under the jurisdiction of the Lancashire authorities.

The northern boundary of the Humber basin is the great east and west watershead crossing England from St. Bees Head to Robin Hood's Bay, north of Scarborough ; but here also the County of York does not follow the physical feature but includes the south bank of the river Tees, which stream forms the county boundary from its mouth to Cauldron Snout, near its source under Cross Fell.

From the Tees the boundary ranges across the hills parallel to the Pennine axis, which it enters at Stanemoor and follows for a short distance, when it passes into the area of the western streams, draining into the Irish Sea.

Southward it again rejoins the Pennine watershed, below Colne, Skipton, and Blackstone Edge, leaving it at Mossley east of Staleybridge, whence it turns eastwards, and follows the minor watershed between the tributaries of the Trent and the River Don which eastward of Sheffield sweeps round by Bawtry and Crowle, to the mouth of the Humber at Adlingfleet.

In Yorkshire, west of the watershed, the rocks range from the *Silurians* to the *Coal Measures*, but the greater part of the area is occupied by the Lower Carboniferous Rocks, consisting of alternations of permeable limestone and sandstone, separated by impermeable shale, nearly the whole of the rainfall is rendered available, as the water absorbed is returned into streams as springs. The Gravitation Waterworks of the Preston and Blackburn Corporation are situated in this area.

Springs containing sulphuretted hydrogen occur in the shale and limestones lying below the Lower Beds of Millstone Grit, they are seen in the bed of the Hodder, and again at Clitheroe where there is a bath-house attached; over the watershed the Clitheroe anticlinal axis brings up the same beds as at Skipton, where the waters were formerly much sought after, which still further to the north-east on the same axis, are the well-known Harrogate mineral waters.

I am not aware that any boring for water exists in Yorkshire west of the watershed; east of it is a boring at Skipton, for Messrs. Scott & Robinson's Brewery, the boring was carried out by the London Diamond Boring Company. The boring is entirely in dark earthy limestone, and was carried to a depth of 500 feet without any alteration in the character of the strata. The water is very pure, but charged on reaching the top of the bore-hole with sulphuretted hydrogen.

The *Yorkshire Millstone Grit* has been very little bored into for water supply, but as the competition for surface water rights increase with the growth of trade and the increase of population in manufacturing districts, its valuable stores of water will doubtless be largely brought into requisition.

From the labours of Professor Green, F.R.S., and those with whom he was associated in the Geological Survey, it would appear that the First Grit (or Rough Rock) and the Fourth Grit (or Kinderscout Grit) are the constant subdivisions, between these two are a variable set of Middle Grits. The Kinderscout thickens steadily from Ashoweve to Keighley and Skipton by Huddersfield and Halifax. It is worthy of note that faults in the Millstone Grit become filled with shale material and form watertight boundaries; water absorbed at the outcrop of the Grit beds flows down the dip, but if let off by a fault the water is thrown out as springs. In the Millstone Grits water is readily absorbed and flows mainly through joints, a supply from this source consequently quickly responds to rainfall, and has not the same retentive capacity as characterises the sandstone of the New Red Series. Barnoldswick, near Skipton, is supplied by a well and boring in the Millstone Grit, at a site chosen by the author.

The *Yorkshire Coal Measures* contain numerous beds of sandstone of considerable value for water-supply purposes. In search of coal their thickness has been proved, but they have not been rendered available for water supply as much as might have been expected. For the following details the writer is largely beholden to Professor Green, F.R.S.

The Oakenshaw, or Clifton Rock is generally a massive full-bedded sandstone, much divided by joints; it is close in grain, and gritty in texture. In some districts it is in two beds, and the upper is called the Shortcliffe Sandstone Bed. The Thornhill Rock is the most important Middle Coal Measure Sandstone in the northern part of the field; it is a close-grained, thin-bedded, valuable building stone, locally traversed by vertical joints. It occurs beneath the *Haigh Moor Coal* and above the *Joan Coal,* and is locally known as the Dewsbury Bank, Morley, Middleton, Robin Hood, and Oulton Rock.

Above the *Parkgate Coal* is the Parkgate, Croppingate or Birstall Rock. At Scholes Colliery it is 90 feet thick; at the Old Pit Moor Colliery 170 feet, where it reaches its thickest; it is thickly bedded, rather coarse, much jointed, and yields a large supply of water, requiring much pumping when it directly overlies the Coal. It was named the Bradgate Rock by William Smith, after the village where it is largely quarried.

The Woolley Edge Rock overlies the *Wathwood Coal* at Wombwell Main, where it is 120 feet 2 inches, with 12½ feet of shale intervening. East of Whitwell Main it lies above the *Wakefield Coal,* and 38 feet of it is described as the "Bleeding Rock," exuding acid water, this blistering the hands of the sinkers. The area of the rock is bounded by a line running west between Pontefract and Castleford, by Normanton; then south by Woolley Edge, passing west of Hemingfield.

Messrs. Mather and Platt have carried out the following borings:—at Walton, Wakefield, 9 inch boring to 770 feet, all in Coal Measures, Coal 4 feet 1 inch at 650 feet. Bradford 24 inch boring 295 feet, at bottom of well 55 feet deep, Coal Measures, to coarse sandstone. Bradford 12 inch boring to 327 feet through Coal Measure Shale, dark grey rock and very hard black rock.

The Oaks Rock is so called at Barnsley. At Trenton and the district south of Sheffield, it is called the Trenton Rock. It can be traced on its outcrop as far as Heath ; east of Wakefield it appears to thin away along a line running roughly north-west, and south-east through Normanton. It usually carries a large quantity of water ; when it is split up with shale the quantity is less. It is largely quarried for building stone and making grindstones, the most important quarry being near Barnsley, where the rock attains its full thickness, it is estimated to be 100 feet, and its base to be 850 feet above the *Barnsley Coal.* At Wath Main Colliery the total thickness of the rock was 55 yards ; it yielded an enormous quantity of water, one feeder alone yielding 3000 gallons per minute, after the tubing was in the shop, but before it was fully "wedged," the yield for months was 18,000 gallons per minute.

The Pontefract Rock is water bearing.

The following is the succession of the Trias and Permian in Yorkshire, given by Professor Phillips :—

Rhætic (?)	10	feet	in thickness.
Keuper Marls, with thin greenish-white sandstone on the top ...	600 (?)	,,	,,
White solid Sandstone, or Waterstone Soft Bunter Sandstsone ... ... Conglomerate of the Bunter... ...	603 (?)	,,	,,
Upper Permian Limestone	45	,,	,,
Gypseous Marls	50	,,	,,
Lower Limestone	150	,,	,,
Sands and Sandstone...	50 (?)	,,	,,

These lower beds are described by Phillips as resembling "the Lower Permian Sandstone of Manchester," and I have no doubt that this identification is correct, and that the Colleyhurst Sandstone of Manchester, is on the same horizon as those of Tynemouth on the east coast. The overlaying Marl Slate of the Durham coast is represented in Yorkshire, by the fossiliferous laminated beds of Garforth. The Lower Limestone contains of carbonate of magnesia 45·7, while the Upper Limestone only contains about 4 per cent. of magnesia. Over this bed are the Knottingley red and pale laminated clays, which would appear to be on the horizon of the Marls associated with the slightly Magnesian Limestone of the Manchester area.

	Magnesian Limestone.	Triassic.	
River Tees, south bank ...	nil	74	square miles.
,, Esk	nil	nil	,,
,, Foulness	nil	72	,,
,, Derwent	nil	?	,,
,, Ouse	50	500	,,
,, Aire and Calder ...	44	96	,,
,, Don	55	120	,,
	149	862	

In the Tees basin, it is worthy of note that the first discovery of Rock-salt was accidentally made in a boring for water, carried out by Messrs. Mather and Platt, for Messrs. Bolckow, Vaughan and Company, commenced in July, 1859, and finished in August, 1863. This boring is now part of the undertaking of the Cleveland Salt Company. The following Table gives an abstract of the information that has been obtained by boring for Salt between this boring and the most recent bore-hole at Lackenby, completed in November of last year, and also carried out by Messrs Mather and Platt :—

	N. Ormesby.		Middlesbro' B., V. & Co.		Imperial Ironworks.		S. Bank Eston.		Lackenby.	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Surface Deposits ...	34	0	70	0	66	6	41	0	13	0
Upper Gypsum Marls ..	242	0	86	0	149	10	453	0	584	0
Red Sandstone and Marls	859	6	902	6	1117	2	836	6	598	0
Lower Gypsum Marls ...	182	9	132	8	203	6	200	0	448	0
Anhydrite and Salt Beds	121	3	114	10	155	3	148	8½	142	9
Magnesian Limestone ...	...		7	4	...		...		...	

The East Coast Saliferous Beds have invariably a bed of Anhydrite as the top, which overlies the "rotten marl" resting on the Rock-salt, beneath which is the Lower Anhydrite Bed, averaging 30 feet in thickness, but abnormally thickening to 267 feet at Hartlepool. The Anhydrite is interbedded, and passes horizontally into the Magnesian Limestone, and the strata from the Upper Anhydrite Bed downwards closely correspond to the Permian Zechstein Beds of Germany, containing Rock-salt associated with Anhydrite.

It was expected that the base of the Lias would have been found beneath the drift, but the boring commenced west of the outcrop, so that the maximum thickness of the Keuper Marls on tke East Coast is not yet absolutely ascertained. On the West Coast they have been proved to be 900 feet in thickness, and as the Rock-salt occurs in the upper 320, it is possible that Triassic Rock-salt underlies the Lias of East Yorkshire, and looking to the maintenance of the thickness of the Rock-salt at the Lackington boring, it is possible that Rock-salt beds occur in North-East Yorkshire of two distinct geological ages.

The following are the details of the Lackenby boring :—

Ft.	In.		Ft.	In.
13	0	Clay and Gravel	13	0
24	0	Hard Red Clay (Gypsum)	18	8
87	0	Red Marl and thin rock	62	4
246	8	Red Marl and band of blue	159	8
255	0	Very Hard Rock	8	4
343	0	Blue and Red Marl	88	4
373	0	Dark Red Marl, blue stone	30	0
380	0	Hard Blue Stone	7	0
597	0	Red Marl	207	0
1195	0	Red Sandstone	598	0
1272	0	Red Marl	77	0
1643	0	Red Marl and Sandstone (63) beds ...	371	0
1663	3	Hard White Rock (*Anhydrite*)	20	0
1672	0	Honeycomb Rock	9	0
1685	0	Salt and Marl mixed	13	0
1804	0	Clear Salt Rock	119	0
1806	0	White Rock (*Anhydrite*)	2	0(+)

The thickness of the beds beneath this boring is not known, but in all cases, borings that have been carried sufficiently deep between Middlesborough and Hartlepool, have proved the Magnesian Limestone to underlie the saliferous beds. It is worthy of note that the rock-salt of the east coast is invariably associated with amorphous sulphate of lime *without* water of crystallization (*Anhydrite*), which in the higher beds in which the sulphate of lime with water of crystallization (*Gypsum*) occurs alone, salt is absent.

Coatham 1567, communicated by Mr. Peacock, M.E. :—

Ft.	In.				Ft.	In.
6	0		1.	Clay	6	0
		Lower Lias.	2.	Blue Shale	39	0
			3.	Nodular band	1	6
			4.	Blue Shale	1	8
			5.	Nodular band	2	0
			6.	Blue Shale	6	4
			7.	Nodular band	1	6
			8.	Blue Shale	21	0
			9.	Bastard post (grey)	5	0
165	0		10.	Blue Shale, hard band	33	0
		Rhætic.	11.	Dark Shale, Pyrites	12	0
			12.	White and grey post, *brine*	9	0
			13.	Red and white mottled posts ...	12	0
			14.	Dark-blue Shale, hard bands ...	19	0
223	0		15.	White Shale	18	0
		Keuper Marl.	16.	Red Marl, Gypsum	74	0
			17.	Hard band	0	2
			18.	Red Marl	23	0
			19.	Hard band	0	3
			20.	Strong Red Marl	9	0
			21.	Gypsum	1	4
341	6		22.	Red Marl	0	9

Works for the manufacture of salt formerly existed on Tod Point, but whether from sea water or a brine spring is unknown. Strong brine was met with in a futile shaft sunk for coal in 1856, on Coatham Marsh by the late Mr. Slate, of Redcar, which led to the above boring being made, which however did not realize expectation.

Boring for coal commenced in 1856, and continued in 1857-8, for Lord Falkland, at Kirk-Lavington, near Yarm, details from Mr. P. S. Reid, Mining Engineer :—

					Ft.	In.
1.	Reddish Clay	27	0	Drift	109	2
2.	Fine Sand	7	0			
3.	Common Sand	4	0			
4.	Fine Sand	10	0			
5.	Reddish Clay	51	0			
6.	Yellow Sandstone	0	8			
7.	White Sandstone	0	9			
8.	Sand and Gravel	4	0			
9.	White Sandstone	1	6			
10.	Sand and Gravel	3	3			
11.	Light-bluish Sandstone				119	10
12.	Very hard White Sandstone				0	11
13.	Light Fire Clay				1	5
14.	Light Shale				2	6
15.	Red Sandstone				204	3
16.	,, Shale and Sandstone				1	0
17.	,, Sandstone Hard				1	1
18.	,, ,, Soft				18	0
19.	,, ,, and Shale				0	3
20.	Very Hard Sandstone				2	3
21.	Shale				7	3
22.	Very Hard Sandstone				2	6
23.	Shale				7	8
24.	Sandstone				4	0
25.	Shale				4	8
26.	Sandstone				2	1
27.	Shale and Clay				2	8
28.	Sandstone				3	9
29,	Clay				0	7
30.	Light Red Sandstone				1	9
31.	Red Sandstone				13	9
32.	,, ,,				3	0
33.	*Magnesian Limestone*				6	9

		Ft.	In.
34.	Red Shale	3	0
35.	,, ,, and Clay	8	8
36.	,, Fire Clay	9	5
37.	*Magnesian Limestone*	6	8
38.	Shale and Clay	2	3
39.	*Magnesian Limestone*	1	6
40.	Red Shale and Clay	5	1
41.	Sandstone hard	9	1
42.	,, ,, ...	4	9
43.	Hard light Red Sandstone	4	0
44.	Very hard ,, ,, ...	1	4
45.	Red Sandstone, shale binds	6	4½
46.	,, Shale, Sandstone binds	16	2½
47.	Grey *Pyritic* Sandstone	1	0
48.	Red Shale, Sandstone binds	24	3
49.	Gypsum	0	9
50.	Red Shaly Sandstone	6	9
51.	Sandstone, Red Shale	20	6
52.	Shaly Sandstone, Gypsum	20	0
53.	Sandstone, Gypsum, and Carb. of Lime ...	17	6
54.	,, ,, ,, ...	6	0
55.	,, ,, ,, ...	14	6
		710	0

Mr. Reid doubts that the beds 33, 37, and 39 were truly referable to the Magnesian Limestone, but Mr. Morley, C.E., considers they belong to that formation, and the underlying beds to the Lower Permian Sandstone.

SELBY WATERWORKS WELL.

Surface 20½ feet above mean sea-level. Yield 250,000 gallons from 6-inch boring carried to 330 feet ; water rises to 4 feet of the surface before pumping ; level restored in two hours.

		Alluvial soil	5	0	75 0
		Clay	24	0	
		Sand (water)	1	0	
		Clay	24	0	
75	0	Quicksand (spring)	21	0	

93	0	Red Sandstone	18	0
93	1	Marl (like Fuller's Earth)	0	1
103	4	Red Sandstone	10	3
103	5	Grey ,,	0	1
167	2	Red ,,	64	9
285	8	,, ,, harder	118	6
296	2	Very hard Rock	10	6
302	11	Red Sandstone	6	9
307	8	Very hard Rock	4	9
329	8	,, ,,	22	0

The water is 8 deg. of hardness.

The following is probably another account of the same boring :—

		Ft.	In.
Drift.	Warp and Clay	10	0
	Strong Clay	10	6
	Sand and Clay	14	8
	Strong Clay	7	10
	Clay and Silt	8	9
	Grey Sand (water)	7	6
	Red Sand	6	6
	Indurated Sand	1	6
	Red Sandstone	54	6
	Red Clay and Fullers Earth, with Pipe Clay	5	0
	Red Sandstone	203	0
		330	0

A well at the opposite end of Selby was carried to a depth of 380 feet, and was still in the Red Sandstone. The water in these wells stands nearly up to the surface, and the Waterworks Well yields 243,000 gallons in 24 hours.

A well at Cawood, 300 feet in depth, is remarkable for the fact that at eleven in the morning of a certain day, the level of the water fell considerably, while at the same time the water at Selby was considerably augmented.

In the district occurring between Tadcaster and York the following sequence and thicknesses of the Trias and Permian Sub-divisions were estimated in 1875 by the late Rev. Clifton Ward, formerly of the Geological Survey :—

		Ft.
Trias.	Keuper Marls, red and blue binds, with sandstone and alabaster beds	400
	Bunter, Red Sandstone	900
Permian.	Upper Marls, thickness unknown	—
	Upper Limestone	40
	Middle Marls	30
	Lower Limestone...	200

At Tadcaster the Lower Permian Limestone was 170 feet in thickness, and rested directly on the Rough Rock of the Millstone Grit.

Towthorpe Common, near York, sunk January to April, 1879. Bore-hole 9 inch diamater and 311 feet 4 inch in depth, subsequently plugged at 210 feet. Water stands 15 feet above the river Fors, and is not affected by pumping. The surface is 60 feet above the sea-level. The section was as follows :—

	Ft.	In.
Top Sand	4	6
Fire Clay	15	0
Boulder Clay	15	0
Loamy Sand...	6	0
Fine Warp Clay	9	0
Grey Sand	10	0
Boulder Clay...	4	0
Green Sand	16	0
Green Sand, with layers of blue bind	18	0
Blue bind or Marl	1	9
Light Sandstone, with blue bind	35	0
White Sandstone	5	0
Blue bind	1	0
Red Marl	2	0
White Sandstone	81	0
Blue Marl	0	6
Variegated Sandstone	23	0
Blue Marl	0	3
Variegated Sandstone	60	0
Red Marl	3	0
	310	0

The hardness of the water (Clark's scale). At the

	At the bottom of the bore-hole :—	At the depth of 210 feet :—
Fixed	66·50	57·35
Temporary	26·25	30·15
Total	92·75	87·50

Sulphate of lime gave nearly 78 grains. and sulphate of magnesia nearly 26 grains.

York.

Messrs, Brett, Sparringate :—

Ft.	In.		Ft.	In.
70	0	Clay and sand, with piece of good oak at bottom	70	0
100	0	Ferruginous sand	30	0
130	0	Sand	30	0
180	0	Gravel and sand (water)	50	0

The surface of the ground here is about 30 feet above the sea, so that the bottom of the bore hole is about 150 feet below it. It is probable that the sand forming the lower part of the last 50 feet is referable to the New Red Sandstone, met with in the other York borings. Water stands 6 feet from the surface, and does not sink more than 2 feet.

Messrs. Steward & Sons, Comb Works, Walmgate Bar :—

	Ft.	In.
Clay and Stones	24	0
Sand	60	0
Fine Sandstone	54	0

The surface of this well is about 50 feet above the sea, so that the surface of the rock here is 34 feet below it. Another boring was carried to a depth of 387 feet in the Red Sandstone. There are three borings in all, yielding 500 gallons per minute.

North Riding Asylum, Clifton.

	Ft.	In.		
Sand	7	0	74	0
Peat	1	0		
Dense Blue Clay	13	0		
Do. Boulders	43	0		
Red Sand	10	0		

	Ft.	In.
Soft Red Sandstone	16	0
White Sandstone	23	0
Red Sandstone, with clay layers	25	0
White Sandstone	10	0
Red Clay	0	6
Red Sandstone	20	0
White Sandstone	8	0
Red Clay	1	0
White Sandstone	15	0
Red Sandstone	3	0
White Sandstone (Water)	2	0
White Sandstone	11	0
Red Sandstone	42	0

Well, at Mr. Swale's, Walmgate Bar:—

		Ft.	In.
	Clay and Stone	24	0
	Quicksand	60	0
	Fine Sandstone	204	0
	Parting (water)	0	2
567 2	Fine Sandstone	270	0

Well at Bilton Hall, near York:—

	Drift	60	0
	Red Sandstone	(+)	

GOOLE.

Boring in connexion with Railway Bridge over the Ouse:—

		Ft.
	Silt and Sand	20
	Black Peat	18
	Soft Brown Clay, Sand, or Gravel	18
	Soft Blue Shale (water)	18
104 0	Strong Blue Shale, with Gypsum	30

HOLME, NEAR MARKET WEIGHTON.

Well at Blacksmith's Arms:—

	Sand (sunk)	15
	Blue "Stone," with layer of "plaster" on bottom	60
300	Blue or Brown "Stone" (? Marl)	225

SALTMARSH.

Sinking and boring in 1834:—

Drift	Earth	36	
	Quicksand	18	
	White and Blue Plaster (Gypsum) and Red Marl	126	201
	Blue Marl	33	
	Red Marl	42	
315	Soft Red Sandstone	60	

DONCASTER.

Boring for water supply. Failed in obtaining one, 1867:—

Warp	4	0	22 0
Blue Clay	14	0	
Quicksand	2	0	
Gravel	2	0	
Red Sandstone	90	0	Up. Marl & Sandstone.
Red Clay	36	0	Upper Magnesian Limestone, Brotherton Beds, 110½ feet.
Limestone	0	4	
Red Clay	1	4	
Limestone	0	8	
Red Clay	1	5	
Limestone	0	1½	
Red Clay	0	6	
Limestone	0	4½	
Red Shale	2	3	
Limestone	0	1½	
Shaly Limestone	6	0	
Blue Clay	0	3	
Limestone	48	0	
Blue Clay	6	7	Middle Marls.
Red Clay with Sulphate of Lime	42	0	
Limestone	210	0	Middle Mag. Lime.
Blue Shot	8	0	Marl Slates (?)

		Fire Clay	18	0	Coal Measure.
		Coal and Marl	18	0	
		Grit	0	9	
		Shaly Clay	84	0	
		Grit	4	6	
845	8¼	Shaly Clay and Grit beds	244	6	

Rods broke, and could not be raised.

Boring at Reedness, upon the estate of Mr. John Egremont, commenced Oct. 7th, 1835, superintended by Mr. John Walker, C.E. The details were obtained by the late Rev. Clifton Ward, who divided the beds as follows .—

			Ft.	In.
		Warp and Gravel	69	0
		Keuper	272	2
1028	10	Bunter	687	2

Dr. Parsons has given further details of this and adjacent borings in the Proc. Geol. and Polyt. Soc. of West Riding, 1877, p. 216.

The *Yorkshire Oolites* occupy the following areas :—

In the basin of the Tees	nil.	
,, ,, Esk	183	sq. miles.
,, xxxvii. basin Ordnance Survey	57	,,
,, xl. ,, ,,	nil.	,,
,, the basin of the Hull	nil.	,,
,, ,, Foulness	8	,,
,, ,, Derwent	57	,,
,, ,, Ouse	42	,,
,, ,, Aire and Calder	nil.	,,
,, ,, Don	nil.	,,
	347	

The average percolation of rain water will be 5 inches annually, or 200,000 gallons per square mile per day, giving an available quantity of 69½ million gallons, or a supply at 30 gallons per head for more than 2¼ million inhabitants. Amongst those who draw upon this supply is the town of Scarborough. The Waterworks Well is near Osgodby, it was sunk in October 1870, and has not been deepened since. It is 160 feet above the sea, and a ten-foot shaft is carried to a depth of 91 feet, with a bore-hole at the bottom 6 inch in diameter carried a further 45 feet, or a total depth of 136 feet. Three headings are driven out from the shaft, with a total length of 70 yards. The water level varies with the speed of pumping and the season, no full record has been kept; the average pumping level is 70 feet from the surface, when 600,000 to 800,000 gallons of water are abstracted. The following is an analysis of the water :—

	Grains per gallon.
Carbonate of Lime	10·150
„ Magnesia	3·129
Sulphate of Lime	3·036
Chloride of Sodium	1·569
„ Calcium	1·792
Silica	·294
Alumina and Oxide of Iron	·126
Organic Matter	·280
Nitric Acid	·376
Iron	Trace
	20·678

Hardness in Clark's scale	
Before boiling	15°
After boiling half-an-hour	5°

Boring at Salton, near Malton, North Riding, carried out in 1880, at 150 feet above the sea, the water overflows the surface from a 4 inch boring, carried to a depth of 316 feet, the water is slightly sulphurous. The section was :—

	Ft.
Fluviatile Drift (R. Rye)	15
Kimmeridge Clay	276
	316

Boring at Irton, near Scarborough, finished August, 1882. The surface bank is 94 feet above the sea. A well was sunk 70 feet, followed by a boring 25 inch for 28 feet; 20 inch for 152 feet; 12 inch for 189½ feet, or to a total depth of 439½ feet. The water overflows the surface at the rate of 1¼ million gallons per 24 hours. The level does not vary, but after heavy rains the quantity increases :—

		Ft.	In.
Drift.	Clay and Soil	2	3
	Gravel	17	0
	Clay	2	9
	Sand and Gravel	0	9
	Marl	1	0
	Sand and Gravel	2	9
	Marl	8	6
	Sand with Boulders	4	9
	Gravel	3	0
	Warp	5	9
	Brown Marl	5	3
	Kimmeridge Clay	44	3
	Rock	21	0
	Very Hard Rock	25	6
	Light Compact Rock	9	0
	Hard Rock	34	6
	Black Coloured Hard Rock	9	0
	Open Rock, with hard binds	19	0
	Hard Rock	94	0
	Soft or Shaly Rock	8	0
	Hard Rock	86	0
	Rock, strong bind	4	5
	Close Rock, mixed with Shale and Sand	14	6
	Blue Shaly Clay	16	6
	Total	439	6

Beneath the *Chalk* of Yorkshire the underlying strata have been uplifted by a gentle anticlinal, from which the beds northwards and southwards, the summit of this anticlinal axis has been truncated and denuded, before the deposition of the chalk, which rests upon the Kimmeridge Clay at Sherburn and the Lias at Huggate, where the upper beds of the Lias were penetrated by a deep well.

At Bridlington Quay occurred the following section :—

Brown Boulder Clay	28 ft.
Hard Conglomerate, Flints and Chalk	15 ,,
Chalk	(×)

An artesian supply of good water was obtained, which ebbed and flowed with the tide.

DRIFT.

Professor Phillips [Geology of Yorkshire, p. 280, Part. 1] long since pointed out that glacial drift fills up an old sea-loch at the Vale of Pickering, and which contain a water-bearing gravel underlying Boulder Clay varying from 30 to 55 feet in thickness. Many artesian borings have been made, the deepest being that at Yeddingham, in the middle of the Vale; they vary from 68 to 95 feet in depth, and the water rises by artesian pressure from 5 to 20 feet above the surface of the ground.

THE DUGGLEBY "HOWE."

BY REV. E. MAULE COLE, M.A., F.G.S.

The high summits of the Wolds are covered with tumuli erected by some ancient British race in the early age of bronze. Indeed, so old are they that only in about 12 per cent. have any bronze relics been found, the weapons consisting almost entirely of flint. Two of these tumuli tower pre-eminently above their fellows, and, curiously enough, both are found in the great Dale, which, starting at Wharram-le-Street in an easterly direction, terminates at Bridlington. One, called "Willy Howe," stands midway between Wold Newton and North Burton: the other is situated at the opposite extremity, at Duggleby, between Wharram-le-Street and Kirby Grindalyth. The former was opened by the late Lord Londesborough, but nothing of interest was discovered. Probably the persons employed were not sufficiently trained to their work, and many things were overlooked. Subsequently Canon Greenwell re-opened it, and ascertained that there had been a grave at the bottom, thus proving it to have been a sepulchral mound. The other has just now been opened by Sir Tatton Sykes, with very remarkable results.

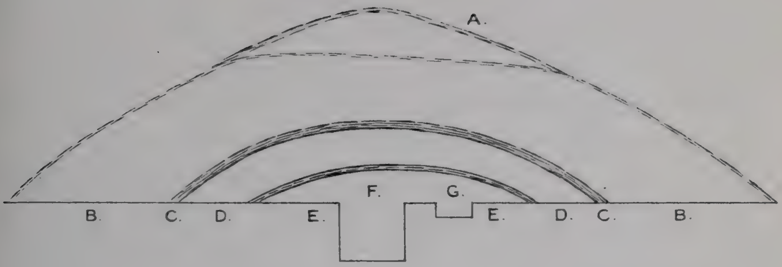
The work was entrusted to the care of Mr. J. R. Mortimer, whose skill and experience admirably qualified him for the task. Operations commenced on July 21st, and lasted for six weeks; the force at his disposal numbering on an average ten men, amongst whom were three experienced hands, Thomas Hebb, Philip Fisher, and Samuel Sedgewick.

The mound was found to be 18 feet high at the western end and 22 feet at the eastern. The original summit had been worn down or removed so as to constitute a somewhat level platform 47 feet in diameter. The base of the mound showed a diameter of more than 120 feet. It was soon ascertained from scattered human bones belonging to two bodies, and numerous fragments of Anglo-Saxon and mediæval pottery, iron scissors, carved bone, combs, &c., that interments had taken place of a more recent date than the original construction of the mound, and that these had been disturbed by a previous opening. It appears that about the year 1798 the Rev. Christopher Sykes, brother of the late Sir Tatton, made an attempt to open the "Howe," but abandoned the task after penetrating to a depth of about 8 feet from the present summit. It next became apparent that this previous excavation had partially destroyed a cross of clay, 2 feet in thickness, orientated, with arms about 10 feet long, somewhat similar to the buried crosses found at Fimber, Wetwang, Swinton and Helperthorpe, whose uses are unknown, though supposed by some to be Roman agri-mensorial marks. Bits of iron, animal bones, and numerous fragments of Anglo-Saxon pottery were found embedded in the arms of this cross, either from subsequent disturbance, or because the cross itself had been constructed in the tumulus later than Roman times.

The upper and outer portion of the mound, as will be seen from the section, consisted of rough pieces of quarried chalk, but at a depth of 9½ feet in the centre of the flattened top, an unbroken bed of dark blue clay, 12 inches thick, was met with, which constituted the covering of an inner mound, whose centre did not quite coincide with that of the outer mound. The clay is that known as the Kimeridge, which, from the denudation of the chalk in the immediate neighbourhood, is exposed at the surface, and therefore easily procurable.

We were now clearly entering on a region entirely unexplored before. The undisturbed bed of clay was succeeded by a concentric ring of small chalk grit, 4½ feet in thickness. In this grit, at various levels, were found a great number of little discs of cremated bones, as shown in the ground plan, nine or ten inches in diameter, but without any urns, or indeed any relics, except, in three cases, remains of burnt bone pins. Cremation is said to be a sign of the introduction of the bronze age; but the cremated bones were generally placed in urns, whilst here there were no urns, nor was any trace of bronze found. Hence this tumulus must claim a very high antiquity.

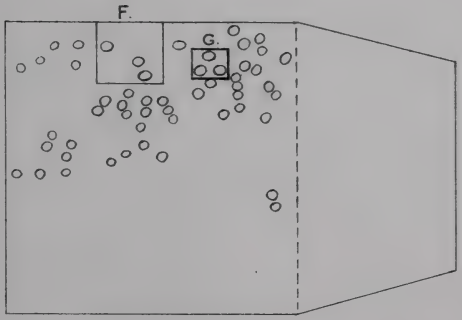
Below the grit a mass of clay, of a different kind from that noticed above, was met with, about 5½ feet thick, resting on the original surface soil. In this clay, as in the grit above, discs of



SECTION OF TUMULUS.

Scale: 1 inch = 30 feet.

a. Supposed Original Height.
b. Rough Quarried Chalk.
c. Blue Kimeridge Clay.
d. Fine Chalk Grit.
e. Reddish Brown Clay.



Ground-Plan showing position of Cremated Bones.

COLE: THE DUGGLEBY TUMULUS.

cremated bones were found, suggesting that a number of persons were sacrificed and burnt at the time that the mound was being raised over the remains of some illustrious chieftain. Proceeding downwards, and testing the ground, a grave was met with under the centre of the mound, excavated 8½ feet in the solid rock. This is an unusual depth, the ordinary depth in the tumuli on the Yorkshire Wolds being only about 3 feet or 4 feet below the surface level, and this fact, combined with the extraordinary dimensions of the Duggleby tumulus, warrants us in supposing that a mighty ruler and warrior was buried here, whose fame and power extended over a considerable portion of the Wolds. Close by was a shallow grave, excavated only 1½ feet in the solid rock, in which, together with a body doubled up in the usual way, were found 6 worked flints, 13 flakes, 10 tusks of the boar, and a fine bone pin, 9½ inches long. In the larger grave in the centre, which had a diameter of 11 feet, and was nearly circular, three bodies had been interred. One, only a foot from the top, was accompanied by several beautiful objects, *e.g.*, a diamond-shaped arrow-head, a fine perforated hammer-head, made of the root-end of the antler of the red deer, and a very fine polished flint axe, 9½ inches long. At the bottom of the grave was the skeleton of an adult, and, near the knees, a semiglobular food vase, so completely crushed as to be beyond all hope of repair. 9 flint flakes and 2 rough cores, from which flakes had been struck, were also found with this interment. It is a matter of conjecture which of these two bodies was the principal one. The beauty of the weapons would seem to point to the upper one, whilst, on the other hand, the position at the base is that usually assigned to the most important personage.

Between the large central grave and the shallow one close by lay, on the old surface level, the remains of a tall man whose femur measured 20 inches. The body had been deposited on the edge of the large grave, and in the process of settlement the head and shoulders had sunk about a foot below the other portions which rested on undisturbed ground. In front of the face was found a very beautiful flint knife, of an uncommon type, ground down on both sides, and extremely thin.

Altogether eleven perfect skeletons and 53 discs of cremated human bones were met with in the course of exploration, and the whole of them found underneath the undisturbed blue clay which constituted the covering of the inner mound. It must also be noticed that detached fragments of unburnt human bones were met with here and there, and notably portions of the skulls of infants. These must have been thrown in haphazard as the mound was being raised.

The opening of this interesting tumulus by Sir Tatton Sykes, under the able supervision of Mr. J. R. Mortimer, yields the following important results :—

1. That the weapons are all of flint of the polished stone age.
2. That no trace of bronze was met with.
3. That no urns or remains of pottery were found with the solitary exception of the food vase mentioned above.

And 4—a fact which is quite unique in the records of other openings of tumuli in England—that no less than 53 deposits of burnt human bones were discovered lying above the interred remains, in little shallow holes an inch thick, either in the chalk grit or underlying brown clay.

PRE-HISTORY OF THE VILLAGE OF FIMBER : PART II.

BY J. R. MORTIMER.

In my previous paper I have shown that the site of Fimber had been long occupied in Pre-Roman times. In this paper I hope to give sufficient evidence to show this village, or some place near to it, to be the probable site of the long lost Delgovitia.

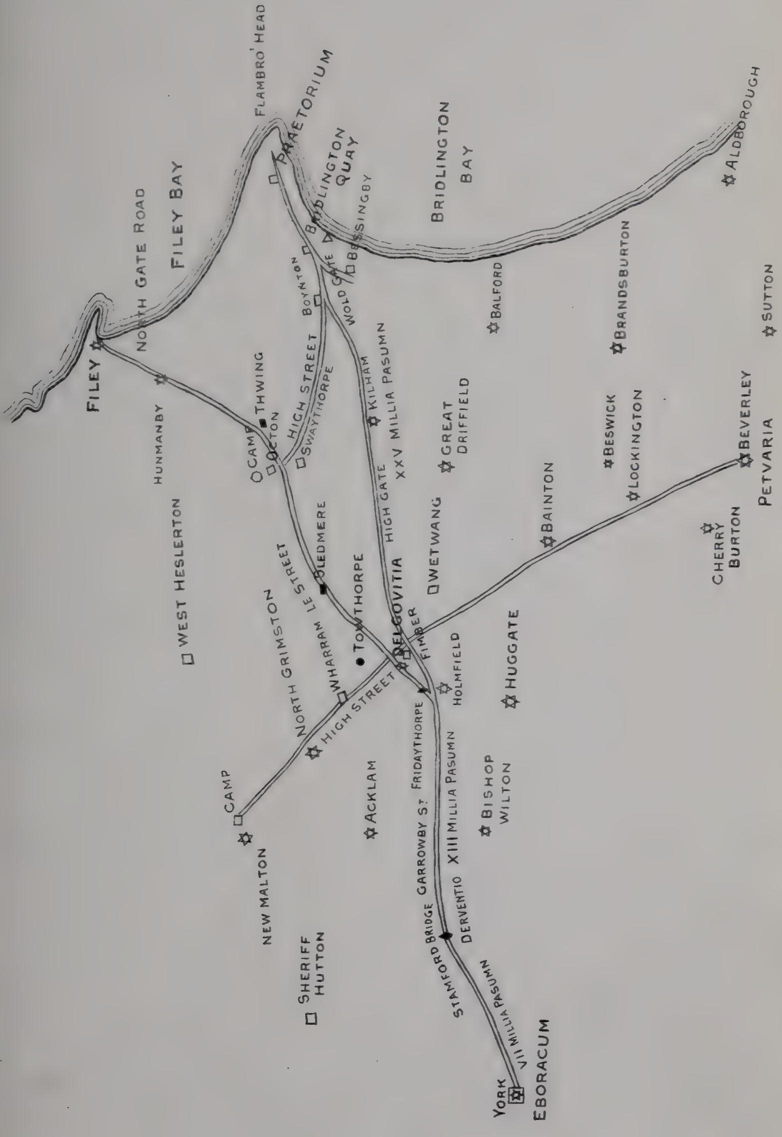
Between Fimber and Wetwang, in the valley called "Bessingdale," near the corner of a British entrenchment, at a point designated "Blealands Nook," where the railway crosses the green lane, a Romano-British grave yard has been discovered. At this place (see accompanying map) the Roman road from Malton to Beverley *(Petvaria ?)*, crossed that from York *(Eboracum)*, through Bridlington to Flambro *(Prætorium ?)*.

The first discovery in this graveyard was made in December, 1868, in fixing the telegraph post which stands where the railway crosses the green lane. The body of an adult was then removed by a workman, but no relics were observed with it. A notice of this discovery was published shortly after in the *Malton Messenger*, and in the *York Herald*, in which notice it was erroneously stated, that the body was accompanied with flint tools.

The second body was discovered in March, 1873, by labourers planting quickwood along the south side of the railway, 20 yards south-east of the body at the crossing, and was said to be in a doubled-up position, with its head towards the north. Nothing was associated with it. This discovery being made known, I obtained the skull from the workmen, and got permission from the North-Eastern Railway Company to make further search within the boundaries of the line. During May 9th and 10th, 1873, and several succeeding days, I examined the ground between the quickwood fence and the embankment of the line, and at the point marked "A" on the accompanying plan a small grave-shaped hole was met with about 2 feet deep, containing dark soil, mixed with bits of burnt wood, and a few calcined human bones, but no relics. A body (No. 3) lay 3 feet 10 inches deep in an oval grave, 7 feet by 8½ feet. on its left side, the knees much drawn up, both arms bent over the abdomen, and the head pointing a little east of north, the femur, tibia, and humerus measured respectively 16, 12, and 11 inches, and were probably those of a female. The right humerus was more than ¼ of an inch longer than the left one. About 8 inches under the feet of this body was the tibia of a stag or small ox; whilst at a depth of 3 feet under No. 3 lay a body (No. 5) on its chest, extended at full length, except the right leg which was slightly bent at the knee; the left arm was bent, with the hand under the pelvis, and the right arm was laid straight by the side of the body, the head pointed in the same direction as the head of the body No. 3. The femur measured 17⅜ inches, the tibia 13¼ inches, the humerus 12½ inches, and belong probably to a male.

A body (No. 4) was placed about 20 feet east of the last one, in a grave similar in form and size. This body rested on the left side with the head directed a little east of north; the knees were much drawn up, and both the hands were placed in front of the face. The femur measured 18 inches, the tibia 13¾, and the humerus 12⅝ inches. A body (No. 6) was placed 3 feet deep, it was much doubled up, and, except that it was laid on the right side, its posture was the same as No. 4. The femur, tibia, and humerus measured 16¼, 12½, and 12 inches respectively. About 12 feet east of the last grave a similar one was found, but the interment had been disturbed at the time of planting the quickwood fence, and most of the bones had been broken. Near to the bodies No. 3 and 5 was the greater portion of the skeleton of a pig, within a rude cist of large chalk stones. We found several places where the white chalk gravel of the valley bottom had been excavated and refilled with dark soil, freely mixed with broken and unbroken animal bones, and also with numerous fragments of many kinds of coarse Roman pottery, but it was observed that no potsherds accompanied the bodies in any of the graves.

Second Examination, February 20th, 1874.—A further examination was commenced in that part of the adjoining field contiguous to the north side of the line. The first discovery was a body (No. 7) placed in an oval grave, 6 feet by 4½ feet and 2¼ feet deep, in the position shown on the plan. The femur measured 15¾ inches; the tibia 12½ inches; the humerus 11¾ inches; and the bones probably belonged to a small female.



Mortimer: Pre-history of Fimber.

No. 5 lay 4½ feet north-west of the last, at a depth of 3 feet, and also on the floor of an oval shaped grave. The femur measured 16¾ inches, the tibia 4¼ inches, and the left and right humeri 12 and 12¼ inches respectively, and though short were of strong make, probably those of a male. The under jaw of this body was curiously deformed, probably from some injury or the prolonged growth of a large abcess. The vertibræ also were much anchylosed.

No. 9 was doubled-up like the last, but was laid on its left side, at a depth of 2½ feet beneath the surface. The femur measured 17¼ inches, the tibia 14 inches, and the right and left humeri 12¾ and 12⅜ inches respectively.

No. 10. The position of this body was similar to that of No. 9, except that it had the legs a little more drawn-up, the knees being within 7 inches of the chin. The femur measured 16¾ inches, the tibia 13¾ inches, and the humerus 12½ inches.

No. 11 lay 4 yards to the south-east of the previous one, in a like position, and at a depth of only 10 inches; the femur, tibia, and humerus measured 16⅛, 12¼, and 11¾ inches respectively. Immediately beneath this body lay No. 12, on its right side, and in a less flexed position, as shown in the plan. The femur measured 16 inches, the tibia 12 inches, and the right and left humeri respectively 11¼ and 11 inches.

No. 13 was the body of a young person, in the exceptional position of being on its back, with the head to the south, both knees were drawn-up to the chest, and pressed over to the left side, the right arm was doubled with the hand by the side of the face, the left arm extended by the left side. The femur measured 12½ inches, the tibia 9½ inches, and the humerus 8¾ inches.

A little east of No. 11 was a dish-shaped excavation, marked "B" on the plan, 2 feet deep, containing wood ashes mixed with calcined human bones. Close to these were part of the lower jaw of a stag, and a portion of the jaw of a large pig. This dish-shaped excavation had been made in a filled-in trench of small width.

Third Examination, April 25th and 27th, 1874.—On these days we trenched a considerable area at the south-eastern corner of the crossing on the south side of the railway, with the result of finding body No. 14 in an oval grave 2½ feet deep. Its position, excepting the arms, was almost exactly the same as No. 12. The left thigh bone was absent, and had probably been removed in digging for rabbits. The right femur measured 17½ inches; the right tibia 13¾ inches; the left tibia 13½ inches; the right humerus 12½ inches; and the left humerus 12¼ inches. In the neighbourhood of the last body the ground had been much disturbed, and in several places small trenches were observed running north and south, or nearly in that direction. Mixed with the soil filling these trenches were a few fragments of dark-coloured pottery, and the teeth and bones of animals.

Just within the line of the railway, near the south side of the quick-wood fence, and about 20 yards south-east of body No. 14 was a small grave 2½ feet deep, containing the remains of a goat, which had been buried in its flesh, as all the bones were in position.

We believe there can be little doubt that the bodies exhumed at Blealands Nook are part of those of a Romano-British cemetery, and that many more lie under the railway, the embankment of which covers an area of 41 feet wide running through the centre of the cemetery, and as there is nothing on the surface to indicate their existence, probably many more remain undiscovered outside the railway, though we have examined the ground in several places. The oval form of the graves and the flexed mode of disposing of the bodies, except in one case, are distinctly British features, and such as we find in nearly every barrow; yet the almost constant orientation of these bodies is in striking contrast to a similar number of bodies from any British barrows known to me. Out of the twelve perfect bodies eleven had their heads to N. and N.E., the twelfth was to S.S.W., whilst six rested on the left side, four were on the right, one on the back, and one extended on the chest. In addition to the bodies by inhumation, there were two (A and B on the plan) by cremation. What is also exceedingly interesting is the fact that the inhumed bodies of the pig and the goat had been interred with the same amount of care as had been given to the human bodies. This, however, is not the only instance of the discovery of carefully interred animal remains in this neighbourhood.

In barrow No. 172 of my openings I found the body of a pig, and also that of a young goat or sheep, both sharing the same grave with the body of a Briton, under a small barrow; and Canon Greenwell found two goats accompanying a body under one of the Danes graves tumuli near Driffield ; whilst a horse and a pig accompanied a body in one of the barrows on Arras, opened by the late Rev. E. Stillingfleet during 1817.* At Fimber the animals had cists to themselves. These Romano-Britons also show an anatomical feature of interest which has been seldom noticed in any bodies from the barrows.

It is this ; the measurements in most cases show a marked difference in length and strength between the right and left humeri. Had the bones of both arms, in all or more cases, been sufficiently preserved and uninjured to have admitted of a careful measurement, probably there would have been more striking examples of this interesting feature. Might not this unequal length and strength of the right arm over that of the left have been developed by the constant training, during youth, in the art of using the spear and throwing the javelin ?

The length of the long bones show them to have belonged to rather small persons. It will be observed that no fragment of pottery was found in any of the graves, though it was found with numerous animal bones abundantly in disturbed ground and trenches close by. Neither, as before mentioned, were any of the bodies accompanied by any relics, which, in this feature also, contrasts greatly with barrow burials and with Anglo-Saxon interments. It seems almost certain that a small Roman station or settlement existed near here at the time of these interments.

This appears further evident from the existence of a series of filled-in trenches, arranged somewhat in the shape of a gridiron near the south-west side of the graveyard (fig. 13). These trenches, like the graves, are quite invisible on the surface, but being mainly charged with rich soil, they are in a dry season indicated by green ribbon-like lines or strips in the growing corn.

The plan of these trenches was obtained by digging numerous sections during the summer of 1874, a few of which I give with measurements. It will be observed that they differ a little in width and depth (which may be due to the slight variations in the surface level of the land, and from the makers endeavouring to keep the bottom of the trenches tolerably clear) but they averaged about 5 feet in depth, and varied in width at the tops from 6 to 14 feet, and at the bottom from 1 foot to 2½ feet.

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* Oliver's History of Beverley, p. 4.

It is difficult to understand the special purpose this system of trenches served. But the single trench running north-westwards may at times be traced by a green strip in the growing corn, extending all the way along the valley bottom to within a mile of Burdale, where a surface stream of water from a fine spring there disappears beneath the turf. I obtained a section of this trench (July, 1884) at a point only half-a-mile from the sinking end of this stream. Therefore this trench may have been connected with the Burdale spring, whose water it conveyed (probably through pipes made of hollowed trunks of trees) to the series of trenches at Blealands Nook to supply with water a settlement there. If this surmise be correct, we have indications of a system of waterworks greatly in advance of any recent arrangement to supply this neighbourhood with good water. This extended line of trench, running towards the Burdale spring, has shown itself in the corn crops every dry summer since I can remember. Indeed its green appearance was noticed by the old men of the neighbourhood, especially my father, whose land it crossed about 1½ miles west of Blealands Nook, and was thought to be the result of a subterraneous stream or watercourse which existed beneath and gave moisture to the land above. If these trenches were not made to convey water, might they have been for a defensive purpose? viz., a series of trenches from the shelter of which slingers and javelin-men cast their projectiles in protecting this crossing of roads and in defending their dwellings, some of which may have been arranged in rows in the spaces between the trenches, whilst the trench extending westwards may have been a covered way.

These trenches, as before-mentioned, were filled with dark soil, containing many animal bones, and much broken Roman pottery, showing this spot to have been occupied in Roman times. Besides these we found a disc of bone (fig. 1), having on one side eight

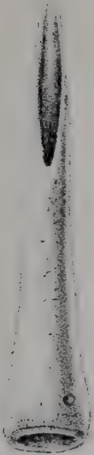

FIG. 4. $\frac{2}{3}$

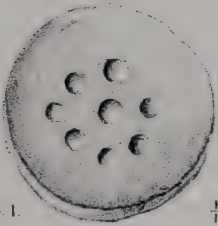

FIG. 1. $\frac{1}{1}$

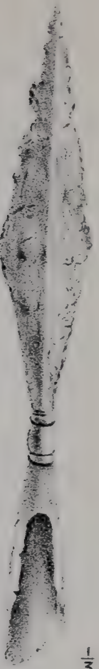

FIG. 5. $\frac{1}{3}$

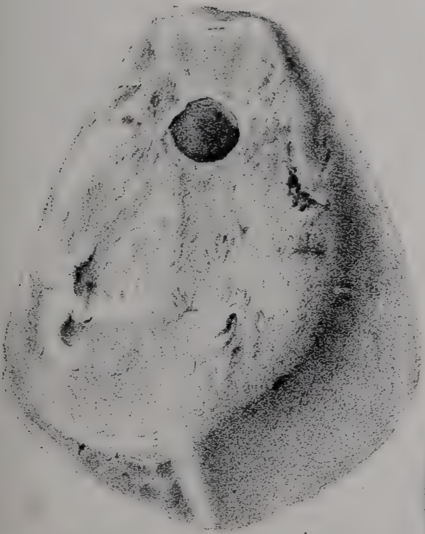

FIG. 2. $\frac{1}{2}$

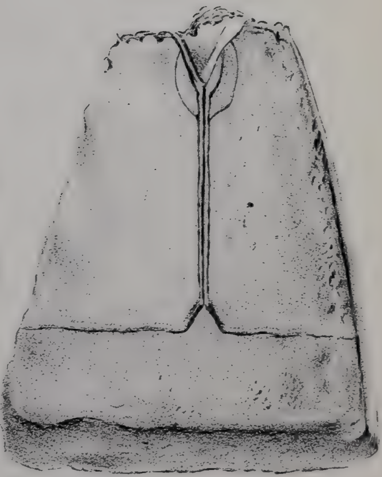

FIG. 3. $\frac{1}{2}$

Mortimer: Pre-history of Fimber.

small cup-shaped hollows, which may have been used as a counter in some game resembling dice. There were also found a rough pear-shaped piece of chalk (fig. 2), pierced near the small end, which had probably served as a weight or plummet; a flat polished piece of chalk (fig. 3), with lines incised on one side; and a sharp-pointed bone implement (fig. 4), made from the shank-bone of the goat, which has a small hole through the socket-end to secure it to a handle. It is quite similar to several bone articles found at Grimthorpe with a late British interment, which was accompanied with an iron sword in a bronze sheath, the bronze covering of a circular shield and other articles* described by me, and figured in the Reliquary for January, 1869, (fig. 5.)

The many animal bones found everywhere in the trenched ground were chiefly those of the horse, always detached and often broken, showing that the flesh of this animal had afforded a large portion of food to the occupiers of this settlement. This, taken in connection with the relics which have been discovered, seems to indicate, as previously pointed out, the site of a Roman or Romano-British station, protecting, as I suggest, the crossing of three Roman roads. The series of buried trenches already described, which extend to near where the present stream disappears beneath the surface, and used for conveying water, is just such a provision as would be required at a station holding the crossing of three roads, at a point where no natural spring exists. A work of this kind is what the Romans would be likely to make, who have always shown great care in the supplying water to their camps and stations whenever required.

Names, implying Roman origin, still linger in the immediate neighbourhood. The present road going up the hill near Fimber Station northwards in the direction of Wharram-le-Street and on to Malton is called "High Street," and a dale leading from Fimber to Burdale is called "Haggdale and Haggdale Cliff,"† names which seem to recall their Roman origin, whilst the ground at the north-west corner of the entrenchments which enclose Fimber is called

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* Now in the British Museum.

† Haggdale, probably derived from the Roman Agger, a bank or mound, as there are remains of large ditches and banks crossing this dale.

"Peasborough" (which probably means road to the Camp), and a little eastwards along the same entrenchments the fields are named "Scaleborough." These, as well as the affix "ber" in Fimber,* plainly indicate the locality of a camp or fortified place.

The iron spear-head (fig. 21) found in the dry summer of 1884 in the mud at the bottom of the most easterly mere in the centre of the village, may have belonged to a Roman soldier; whilst in the centre of the village, between the two meres, was a small hole which, when I was a boy, held water, it was then known by the name of well-hole, spring-hole, and frost-hole. This place, if examined, might prove to be a Roman well and yield relics of much historical value. In the York Museum is a fine cinerary Roman urn, of glass, ticketed "found near Wharram-le-Street, on the Roman road passing Fimber, in 1820, and presented by the Rev. J. W. Stillingfleet." In a straight line 1½ miles S.S.E. from Blealand's Nook, in the direction of Beverley, is a little valley called "Thorndale," which is certainly on the line of this old Roman road from Malton to Beverley. Professor Phillips says† "thorn is seldom far from old camps or mounds of importance." From Thorndale this old road is in places distinctly traceable in a straight line towards Beverley. It crosses Tibthorpe Wold close to the farmhouse called "Angas Farm," where, in the year 1850, in excavating for a well on the north side of the house, several bodies were exhumed, but their positions were not observed, neither is it known whether they were accompanied with any relics or not. About one mile S.S.E. this old road is well shown, running obliquely over the north side of Bainton Heights, in a line with Bainton and Beverley.

The existence of a Roman station near the site of our discovery is, to my knowledge, first intimated in 1847 by John Yonge Akerman, in his "Archæological Index, page 148, where he presumes Fimber to be the site of Delgovitia. This site is also favoured by Prof. Phillips,‡ who is inclined to Derventio being at "Stamford

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* Anciently spelt "Fin-mere" without the 'b;' probably this was a local corruption, originating from the existence of two fine meres in the centre of the village, and that the present spelling is a survival of the meaning of the name.

† Rivers, Mountains, and Sea-Coast of Yornshire, p. 242

‡ Rivers, Mountains, and Sea-Coast of Yorkshire, pp. 241-42.

"Bridge, and Delgovitia somewhere about Huggate (great banks), or "Wetwang, and Prætorium at, or near, Bridlington." He also adds. "Roads which appear to be of the Roman period, lead from Malton "towards the Wolds, as by Wharram-le-Street towards the point "between Fimber and Wetwang, agreeing with the supposed position "of Delgovitia on the road to Bridlington." If we regard the cemetery between Wetwang and Fimber and other remains to be the approximate site of Delgovitia Bridlington is too near to be Prætorium, but there may have been a small coast station* at Bessingby, near Bridlington, where are remnants of earthworks, and from which an old hollow road strikes off into the main Roman road leading through Bridlington and on to Flamborough *(Prætorium).*

Many Roman coins have from time to time been picked from the surface of the land near the crossing of the Roman roads and in other places near Fimber, most of which have not been preserved. Two of several picked up during the winter of 1885, near Blealands Nook, by a shepherd, are in my possession. The one is of Constantine, the other of the son of Constantine.

Let us now follow this Roman road from York to the sea, and by the aid of the map we shall find that on its leaving Stamford Bridge, passing along Garrowby Street, past Wayrham, and a little before reaching Fridaythorpe, it bifurcates, one branch (called by the old inhabitants "Low Street"), passing along the Green Lane, near Holmfield, to Blealands Nook, the site of our Romano-British graveyard, then on to Kilham, and straight along the old road known as "Wold Gate," through the old streets of Bridlington, called "West Gate" and "High Street," and straight along the old terrace-like bank near Sewerby, named "Under Gate," to Flamborough, which very probably, as before mentioned, was Pærtorium.

Bridlington has not sufficient natural features to recommend it as a secure place for an important terminal station.

*** Just lately (1885) Mr. Boynton, of Ulrome, has discovered on his farm, six miles south of Bessingby, a filled-in trench, apparently the vallum of one side of a small Roman Camp belonging to one of the line of garrisons which were placed along the east-coast to protect the country from the invasions of the Saxons, who even then made several attempts to gain a landing. This vallum contained animal bones and great numbers of fragments of all kinds of Roman Pottery.**

During Roman times, the now existing bay was land stretching far out to sea, probably nearly in a line with Flamborough Head, and only a small bay then existed.* The site of Flamborough, however, possesses rare advantages: from the sea it would be almost impregnable, whilst on the land side is one of the most perfect and grand artificial earth-works of its kind in England, known as "Danes' Dyke." This stupendous rampart, resembling more the Roman earthworks than the ancient British entrenchments of the neighbourhood, but which certainly is not later than Roman times, reaches from sea to sea, cutting off the promontory and forming a vast and almost impregnable camp, whilst Filey is at an easy distance, and would then be a safe bay for a large number of Roman galleys, and as there exists near the "Brig" remains of the foundations apparently of an old pier, believed to be Roman, this place was probably the well-havened bay of Ptolemy, and could readily communicate either by land or by water with Flamborough *(Prætorium).*

We will now follow the other branch road (the old name for which is "High Street,") from Fridaythorpe through Fimber, close past the railway station, where it is also crossed by the Roman road from Malton to Beverley; it then passed through Sledmere†; past Cowlam, where about 1860 a large quantity of Roman coins, many of which I possess through the kindness of C. Sykes, Esq., M.P., were found in a vase, and where are extensive old foundations, probably dating back to Roman times, which are a promising field for excavations; straight on to a point between Octon and Swaythorpe‡ where there is a supposed Roman camp. Here it again bifurcates, one branch passing northwards a little to the north-west of Thwding|| (which denotes two roads), and probably along the old raised bank, crossing the fields in a straight line close to the left of Willy Howe,

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* A rather low estimate of the waste of these friable cliffs during 1800 years must have been two miles, whilst the indurated rock of the "Head" has been driven in but little.

† Here the late Sir Christopher Sykes discovered a portion of this road near the Sledmere mere laid in a convex form. 9 feet wide, 6 to 7 inches thick. It was over 2 feet from the surface.—Allan's History of Yorkshire, p. 14,

‡ Swaythorpe, in "Doomsday Book," is Suanetorp and Svavetorp.

|| Derived, according to Mr. Holderness, from two Anglo-Saxon words "Tue," double, and "Geng," a way or path. meaning two roads.—Driffield Observer, Sept., 7th, 1878.

a noble land-mark; and then on to Hunmanby and along North Gate Road, past Thorn Balk (denoting the site of a camp) to Filey, where, according to the best authorities, there was a Roman port.

The other branch passes to the south of Thwing eastwards through Rudston, Boynton, and joins the more southern and direct line to the sea, a little to the west of Bridlington on the road to Flamborough.* Both the trunk and the two branches of this road to the sea ran for considerable distance by the side of British entrenchments, which also seem to have led to the coast. The old writers have often mistaken these entrenchments for Roman roads, and thus muddled the two together.

If we now compare the distances between the stations given in the first iter of Antonine, we shall find that Blealand's Nook and Fimber agree closely with the given position for Delgovitia on this line of stations.

The iter gives the distance between Eboracum and Derventio as vii. millia passuum which are equal to about 6½ English miles. which is the distance between York and Stamford Bridge. The distance between Derventio and Delgovitia is given as xiii. millia passuum, which nearly makes 12 English miles, the approximate distance between Stamford Bridge and Blealands Nook, the site of our discovery, and the exact distance between Stamford Bridge and the village of Fimber. Whilst the distance between Delgovitia and Prætorium is xxv, millia passuum, or about 23 English miles, being the almost exact distance between Fimber and Flamborough, the most probable Roman Prætorium. And if we measure the distance from Fimber along the northern branch to Filey. it nearly reaches the distance given by the iter between Delgovitia and Prætorium.

There is no place we believe that answers so well to the given distance in the itinerary or has a better claim from its position and discoveries to the site of the long-lost Delgovitia than has the immediate neighbourhood of Fimber, just within the main fork in the road to the coast where it is crossed by the Roman road from Malton to Beverley.

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* Drake, Tuke, and Newton mention this Roman road between Rudston and Bridlington.

Fimber is about midway between the Roman centre Eboracum and Prætorium, and also is nearly half-way between the Roman station at Malton and that at Beverley. It is true that no trace of the ramparts of such a camp as we might expect to find at a Roman station has as yet been discovered, but then, during the cultivation of the land and other operations of the husbandman during the lapse of fourteen centuries, it is highly probable that in this case, as in many others, such a structure has long since been swept away; though it is not improbable that the filled-up fosse of such a camp may yet be discovered; or it is possible that Delgovitia may have been more a trading or commissariat depôt from which the Roman legions were fed on their march from Eboracum to Prætorium, on the east coast, than a military camp, and that the Romans mainly occupied the site of the village of Fimber, and as suggested by the Rev. J. Wiltshire,* may have strengthened and made use of the extensive British earthworks which have surrounded and protected this village, and which are now distinctly traceable on the surface, resembling a huge camp, as shown in Part I. of my paper.† In support of this view Professor Phillips in his Rivers, Mountains, and Sea-Coast of Yorkshire, p. 246, says, "Derventio and Delgovitia may perhaps never have been marked by camps."

Except Fimber being the presumed site of Delgovitia in the "Archæological Index," and Prof. Phillips' cautious hint that Delgovitia may have been somewhere about Huggate or Wetwang, and that the point between Fimber and Wetwang agrees with the supposed site of Delgovitia on the road to Bridlington, I know of no other allusion to this station being at or near Fimber.

I think the Rev. E. M. Cole, in a recent paper "on Ancient British Entrenchments," is slightly in error when he says, "In this case Fimber may be the lost Delgovitia as already suggested by Knox and Phillips."‡ I cannot find that Knox makes any allusion to Delgovitia being at Fimber. I am pleased however to find Mr. Cole is now more favourable to this site than at the reading of my paper in 1884.

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* In the Proceedings of the Geologists' Association, No. 8, 1862.

† Vol. xi., pt. ii., p.

‡ Proc. Yorksh, Geol. Polyt.. Soc., vol. xi., p. i., 1889.

From the discoveries I have made at Blealand's Nook and other proofs, I think it may be admitted that the Romans occupied the neighbourhood of Fimber, which is on the line of the most direct road from Eboracum to the east-coast, being, as before-mentioned, about midway between the two, and at a point where this road is intersected nearly at right angles by the Roman road from Malton to Beverley, and therefore just where a Roman station would certainly be required. This site (as before urged) seems to possess a greater claim to be Delgovitia than any of the numerous places which have been previously assigned to it. I therefore hopefully wait for further proofs, from future discoveries, to support my views.

A SUPPOSED ROMAN CAMP AT OCTON. BY J. R. MORTIMER.

These earthworks being in very old grass are, except the west end, in excellent preservation; but had the ground ever been under the plough, no trace of the ditch and two ramparts would now have been visible, and future excavations would only have discovered the filled-in trenches.

The present appearance is that of two nearly square contiguous camps. They are situated on the north side of the Roman road to the coast, in a rather sheltered and secluded place, which is somewhat unusual for a Roman camp. This camp cannot be seen until closely approached, yet sentinals placed on elevated ground a few paces away would be able to see the advance of an enemy for a considerable distance all round, and quickly signal to the defenders within.

The form of this camp is shown on the plan (fig. 1). Its most eastern portion is quite perfect, and measures 80 yards by 68 yards internally, whilst its western and somewhat larger portion is not so perfect. The west end of this division of the camp is obliterated by the foundations of old buildings, which at one time stood upon it.

This camp possesses a very uncommon feature. Its main and probably only entrance, unless there was one in the west end, now obliterated, seems to have been by a deep sunk way entering its southern side through the outer rampart into the ditch, and continuing across the camp as far as the northern side ditch, thus cutting it into two nearly equal parts. In excavating this foss-way across the camp, the material has been cast on both sides forming two banks or ramparts, hence the resemblance to two nearly square contiguous camps; but it really seems to be only one camp in the form of a parallelogram divided into two compartments by this sunk entry. It will be observed that to gain admittance into the interior of the camp without scaling the ramparts, it would be necessary to traverse the whole length of the foss-way as far as the northern side of the camp, and then to turn and pass for a few paces to the right, where there is a well-preserved opening, 28 feet wide, through the inner rampart, into the interior.

By this ingenious arrangement ingress was rendered extremely difficult for an enemy, who, after forcing the outer entrance gate, would have to make his way almost in single file along a deep and narrow avenue the whole width of the camp, and for a short distance along the northern side before the second gate leading through the inner rampart into the interior, as shown on the plan, could be forced. Such a well-defended entrance as this camp possessed would expose an enemy passing along it to a full attack from the defenders inside the ramparts on both sides of the passage, and give a small number of men with minor weapons great resistive powers.

It is true, that after forcing the outer gate of the subway, the attacking party would enter and push along the foss running round the side of the camp, as well as by the centre passage. But so long as the inner rampart was unscaled, the enemy in the trenches would suffer greatly from the defenders sheltered within the camp, and soon be reduced to an almost helpless mass of wounded and dying men. Such a condition of things would block the trenches, impede further ingress, and act somewhat as a barrier to the enemy without, striving to scale the ditch and inner rampart. Probably there would also be a similar entrance somewhere through the inner rampart into the western division of this camp, which entrance is now obliterated by débris which at some time has been carted and in places shot into the foss-way.

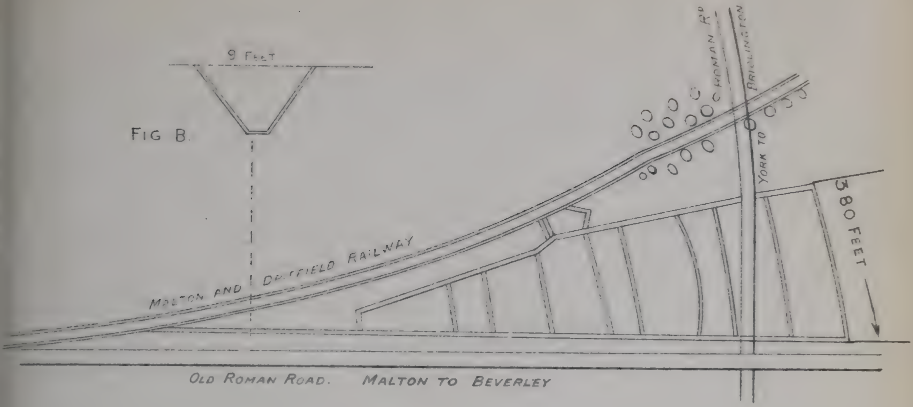
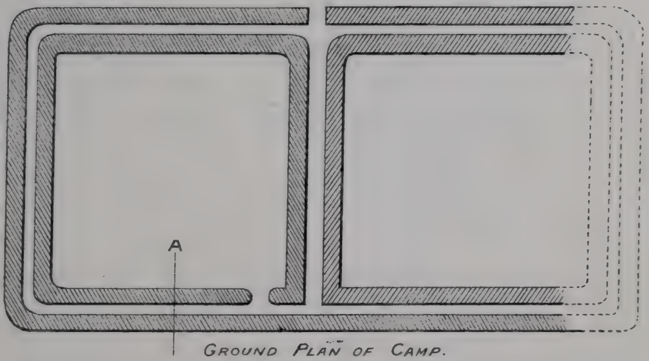

9 FEET
FIG B.
MALTON AND DRIFFIELD RAILWAY
ROMAN RD
YORK TO BRIDLINGTON
380 FEET
OLD ROMAN ROAD. MALTON TO BEVERLEY

FIG. A. System of Trenches at Bessingdale.

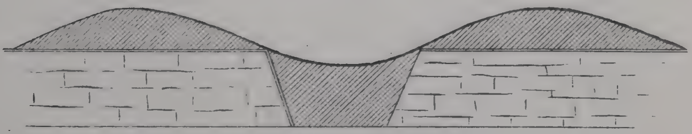
0 Mark places where Graves were found.

FIG. B. Section of Trench, 9 feet across, 5 feet in depth.

MORTIMER: PRE-HISTORY OF FIMBER.



GROUND PLAN OF CAMP.



SECTION OF CAMP AT A.

MORTIMER: CAMP AT OCTON.

Through the kindness of Mr. F. Barugh, the occupier of the land, I am able to show you (fig. 2) a section of the ditch and two ramparts, taken on the northern side of the camp at the point marked "A" on the plan. From this section we gather that the material now partly filling the trench is sufficient to have raised the two ramparts 2 feet higher than their present lowered condition, and that originally the distance from the bottom of the foss to the summit of the two ramparts was not less than 11 feet, whilst this formidable barrier may have been still further strengthened by palisades fixed along the top of one or both ramparts.

By its covered entry, which differs entirely from the level entrance observed in the well-recognised Roman camps, such as those at Cawthorn, near Pickering, and others formed on the strict plan of "Polybius," this camp is admirably adapted for resisting any attack from an enemy. Its main purpose would not be aggressive, but to preserve communication between Eboracum and Filey, the well-havened bay of Ptolemy, hence the probable advantage of its somewhat hidden position.

The camp may have been constructed and occupied by a detachment of Romano-Britons, who were allowed to arrange the entrance to the camp somewhat after their own ideas, copied from some of the numerous old hollow-ways of the Britons then in existence. This would account for the entrance differing in this case from the general Roman plan.

SOME PHYSICAL PROPERTIES OF COAL. BY BENJ. HOLGATE, F.G.S.

The behaviour of coal in the different circumstances under which it is used is so varied and complex, and yet of so much importance to our well-being, that I offer no apology for recording observations made with regard to its physical properties and behaviour.

If we first examine the different conditions under which coals are used, and then examine the properties of the coals which have been found best suited to these conditions, we shall learn at least something of the general principles which should guide us in the selection of coals for our different requirements; and, on the other hand, we may, from the behaviour of the coal whilst in use, gather some information as to its origin and the alterations to which it has been subjected since it was deposited.

In this country some coals are used in open fire grates for domestic purposes which burn at a comparatively low temperature, some in boiler furnaces at a higher temperature for the making of steam, and others in reverbatory furnaces at a very high temperature for the heating or smelting of glass, iron, steel, &c. These are all used with a free admission of air.

Again, other coals are used for gasmaking, which I may remind you is performed by the introduction of coals into an air-tight vessel, this, being heated, distils its contents, giving off gas and other substances and leaving a residue of somewhat spongy coke.

Other coals are used for nothing but making coke. In this case the coal is thrown into a chamber, the walls of which have been previously heated to redness, the opening is then built up so as to almost entirely prevent the admission of air. The heat of the chamber slowly communicates itself to the coals, in which operation their structure is entirely changed, some of the volatile gases are allowed to escape at a comparatively low temperature, the remainder forming new chemical combinations as they slowly permeate through the thick body of the coal and solidify into the coke, giving it density, hardness, and strength. The different kinds of coke are required for purposes in which smoke is undesirable, or in which a strong draught or blast of air is introduced for the heating of substances in the body of the fire.

Another way in which coals are used is in the Siemen's furnace; in this case the coal is burnt in an ordinary fire-grate, but with such a small quantity of air that the gas given off is hydrogen aud carbon-monoxide. The completion of the combustion, that is, the changing of the carbon from the monoxide into the dioxide or carbonic acid, and the hydrogen into water, being completed in the body of the furnace, in the presence of the iron, steel, glass, or other substance which is to be melted.

Turning from this to the different kinds of coal, we find them equally varied: first we have the cannel coals which are found in non-continuous basins or hollows, it may be along with other coals or in seams by themselves. Black in colour, they vary in appearance from being shiny, light in weight, and weak, breaking with a conchoidal fracture, to being dull in appearance, black, and dense, but whatever the difference in their appearance they are alike in containing remains of fishes or the shells of molluses, and it is to the fact of their containing animal hydro-carbons that in combustion they give a white light, and for that reason are used specially for gas making owing to the high illuminating power of the gas made from them. The temperature at which the dull-looking cannel gives off its gas is much lower than that at which its solid part fuses, and the consequence is that the coke is not changed in form when it comes out of the retort from that at which it was introduced into it; besides this, as the coal contains a certain amount of mud, the ash is large in quantity and white in colour.

The cannels then were formed under water, and perhaps of masses of floated wood, combined with the remains of fishes, but mostly of trees and water plants that grew *in situ* but in a sinking area and under water in which fishes and molluscs had their habitation, and into which a small portion of fine mud found its way; since that time the animal hydro-carbons have permeated the vegetable matter and the mud, and a hard, compact coal has been formed. There are several seams of coal of this kind in the vicinity of Leeds.

It will be apparant that we must expect to find gradations from the pure cannel to the ordinary bituminous coal, and this is what we do find in fact.

The coal known as the Better Bed, the first seam above the Elland flagstone, and also a portion about 8 inch thick in the middle of the Middleton Little Seam are nearly allied to the cannels. They are the coals known in the text books as being made up in a great measure of spores of coal measure plants. The coals are black and dull in appearance, and if scratched give not a black but a distinctly brown streak. If broken transversely the spores may be plainly seen in immense quantities protruding from the broken face, and a microscopic vertical section shows distinctly the resinous spores, for they are about the size of a pin's head. If we polish a piece of it as marble is polished, which we can do, the resinous spores which are tougher than the other part protrude slightly and show figures on the polished surface. Both seams contain fish remains, and the spores have every appearance of having floated into their present position along with a little mud.

These coals are so tough, that when thrown down or struck, the pieces do not readily break, but ring sonorously. Their toughness and strength seem to be due in a great measure to a small quantity of the animal hydro-carbons together with resinous matter emanating from the spores that has permeated through the mass.

In a fire which burns at a low temperature, such as a house fire, these coals are considered as almost valueless, for the individual bits of coal do not fuse together; the fire does not burn brightly, nor does the ash fuse into clinker, but it flies about the house as a disagreeable white, fine dust. Its behaviour in a boiler furnace is better, but it will not make steam rapidly unless the draught be very great, the temperature not being high enough to derive the best results from it. It is used to best advantage in a furnace working at a high temperature, as are the reverbatory furnaces for melting or heating iron and steel. When thrown into a furnace of this kind (in which case it has finished its work at upwards of 3,000 degrees of temperature, such being the heat of the melted metal or the bloom) it bursts at once into a flame which is so long that it passes through the reverberatory chamber, up a chimney some 30 or 40 feet in height, and finally appears at the top of the chimney.

When made into coke much of it comes out of the oven in the same form as that in which it was thrown in.

The Barnsley coals are nearly allied to the two kinds above-named. Nearly all coals are made up partly of water plants, and were formed under similar conditions to those named above, and more contain some fish remains than are generally supposed to do so.

I have not succeeded in finding any in the upper part of a thin seam known in this neighbourhood as the Crow Coal, of which, through its thinness, there is necessarily but a small quantity in the market. This coal is soft and very suitable for house fires. It contains but a small proportion of ash, gives a bright flame, the fire, without a forced draught, burning at almost a white heat.

It is a good steam coal, but through its softness it burns away rapidly, and makes a great deal of smoke. This coal is of little value as a furnace coal compared with those previously named. It is so hot underneath the fire where the air rushes into it that the fire bars are melted. The flame produced however is so short that it scarcely reaches the iron, and does not fill the reverbatory chamber. Without trying it for gas-making we might safely conclude that it would yield an average amount of gas of an average illuminating power; that an abundance of tar compounds would be given off, and that a soft spongy coke would remain.

Between these two kinds of coal there are many varieties. In some, as in the Middleton Main and the Haigh Moor, we get examples in which spores, though present, are not so numerous as in the Better Bed or the Hards of the Middleton Little. They contain more woody matter, and are sufficiently tough to retain a large size throughout the various handlings to which they are subjected from the time of being taken out of the mine to the time when they are thrown into the furnace.

Their layers of bedding show an alternately dull and bright appearance; they are very suitable for house fires, for raising steam, or for reverbatory furnaces. They are also suitable for gas-making, as they give off a gas of an illuminating power above the average, and make a fairly good coke; they will not however yield up to the average of the tar compounds.

The Beeston Bed is less tough than the above. It does not contain as many spores as does the last-named, and consequently it is softer and more easily broken. It breaks down more readily into small before being used. The upper and the harder part is a good house and a fair furnace coal: the lower portion is also used as a house coal but of inferior quality, also for raising steam. The whole seam is used largely for gas-making, excluding the lowest part or Doggie which is not worked.

The top part of the Middleton Little Coal seam is nearly allied in its properties to the Middleton Main Coal, whilst the bottom part more nearly resembles the upper part of the Beeston Bed.

The middle part I have before described as containing numerous spores, and being suitable for furnaces. There still remains to consider the class of coal that habitually breaks into small, just as those above-named break, some into large and some into medium-sized pieces, and which are consequently poor in quality. Amongst coals of this class, in this neighbourhood, are the Halifax Beds, Black Bed, lower part of Crow Coal and Beeston Beds, both known as Johnnies or Doggies, the latter known also in some neighbourhoods as Churwell Thick and the Shertcliffe Beds.

Here allow me to say a few words about cleavage in coal, to fully understand the importance of which, we should see the coal in position in open workings. In these positions we may see that the whole of the strata, whether of sandstones or shales, through which the coals run in comparatively thin seams, show distinct lines of jointing or cleavage, the distances between the joints varying with the different minerals. The coals themselves, even the different parts of the same seam, vary very much in the distances between these cleavages. We may have a coal cleaving into pieces at about 6 inch wide and attached to it above or below, as in the case of the Middleton Little Coal, one of a totally different kind, cleaving at a distance of only half an inch or even less.

If we examine them closely we shall find that the dull-looking tough coal containing spores or fish remains, cleaves at the greatest distance apart, whilst the coal which presents a shiny, polished surface on its broken face (not its plane of cleavage) is soft and brittle, and has its cleavage planes in close proximity. Between these two kinds we find every variety.

In the Middleton Main and Haigh Moor, the coals are made up of alternate thin layers of the two kinds, the result being, a coal not so tough and strong as if made up principally of spores, and yet much stronger than are the bright coals abovenamed ; it is to this difference in the distance between the planes of cleavage that the usefulness of the coal depends; those which have their cleavage planes wide apart break naturally into larger pieces as above described, and give very different results when used, either for combustion or for gas-making, from those which cleave naturally into thin plates. Coal of the latter kind if thrown on a fire even in large pieces, by breaking up at once into small when warmed, and by preventing a free passage of air, gives the inferior result of a short flame at a low temperature, with a good deal of black smoke. Under these circumstances we are led to the conclusion that coals having pretty nearly the same ultimate chemical constitution, but differing in the distances between the planes of cleavage, give totally different results during combustion. The coals which thus naturally break into small, if used for gas-making, will deliver their gas more slowly, and this gas, as it is liberated, instead of clearing itself and working its way between the pieces of coal, which it would do if they were large, makes different chemical combinations through its being smothered by the surrounding small coal, and so we get less gas. With coals of this kind, notwithstanding the greatest care in firing, much smoke will be made, and every means that has as yet been tried to burn the smoke in furnaces of the ordinary kind, when using such coals have resulted not in economy but in loss of heat and consequently of work.

The reason why Leeds looks so black is accounted for by the fact of so many coals being used here that naturally break into small, as we have described, and so are smoky.

I do not here refer to the Siemen's furnace, in which a far more perfect distillation takes place, and in which but little smoke is made in the circumstance under which it is at present used; if however it were used for boiler firing, its gases would be brought during combustion into contact with comparatively cold boiler plates, and we may safely say that it would then make a considerable amount of smoke.

When these furnaces were first introduced it was claimed for them that small coals would be as well adapted as large, but this was soon found not to be the case. Small coal is in no case as good as large, when the object is to obtain a large quantity of volatile gas, either for combustion or gas making; but small coals make the best coke.

The question which at once presents itself is, How does this cleavage take place, and why is it different even in the same seam of coals?

I will answer the last question first. The whole of the coal measures show us upon examination that they were in a perpetual state of change during deposition, the land, low lying as it was, and subject not only to floods but to changes in the courses of its larger rivers, changed its vegatation to suit the changing conditions, and coals are made up of a great variety of plants, sometimes of huge trees, sometimes of water-plants with their attendant fish remains; and though all went to form coal, they would naturally make different kinds.

When we find beds of fish and shell-remains in the shale we see that the oil from these animals has permeated through the shale hardening it into a marble, and it has had the same effect on the coal in its immediate vicinity.

If we examine coal in the neighbourhood of a fault, we find that it has been cloven in more than one direction, and often it has been so compressed that it has been shattered. In other places we may see lines of cleavage in two totally different directions, and this not only affects the coals but all the strata of shales, sandstones, etc. We know that the land has been repeatedly raised and lowered, and that the pressure causing this has been a lateral one, and we know that wherever we find contortion of the strata, or a proximity to volcanic action, the coals are changed as regards their cleavage.

If we examine a piece of Welsh anthracite we do not wonder that it will not blaze, for though bright in appearance, we see that it has been so compressed and is so slicken-sided in all directions that we can plainly judge the cause from the result.

Belgian coals, which are worked almost vertically owing to contortion, are also much shattered.

The coals which are made into coke by Messrs. Strakers & Love, in West Durham, have been so shattered that they fall into dust if exposed to the weather, and they may be easily crushed in the hand, but though they are very poor as coal, they make the best and hardest coke in the country.

In order to make coke from the coals of our own and the Sheffield district which naturally cleave at greater distances apart, it is absolutely necessary that they should be small, the smaller the better, as by this means the gasses are not allowed to escape, but are condensed into the coke. It is also necessary that they should be washed, not only so as to wash away any dirt, but also any chemical impurities and some volatile gasses whose presence would result in an inferior coke. A very good coke suitable for melting steel and iron is made in this way.

The cleavage spoken of above must have taken place a long time ago, for we find that water containing lime, barium, and sulphide of iron has percolated along the interstices of the cleavage, and has left these substances in a crystalline form. This is another source of inferiority of coals having their planes of cleavage close together, they not only break into small, but they often contain a large quantity of deposited impurities

From what has been said we may draw the following conclusions: the mode of burning and consequent usefulness of coal is governed principally by the sizes into which it breaks down before or after being thrown into the furnace.

Coals dull in appearance having a brown streak and containing many spores and fish remains are tough and break into large pieces. They are suitable for furnaces working at a high temperature, and allow the air to pass freely through them in the furnace. They are free burning.

Bright coals, having cleavage planes close together, are soft and break into small, either before or after they are thrown into the furnace.

They are more suitable for fires working at a low temperature, and require frequent stirring. They contain more fusible salts that have been deposited by the passage of water between the numerous interstices than the dull coals do, and owing to the presence of these salts the ash clinkers in combustion. They intumesce and cake, thus preventing a free and plentiful passage of air. They make much smoke.

Coals which are very soft and break easily into small, make the hardest and most valuable coke. If the cleavage is in more than one direction, causing the coals to break down into dust, they make the best coke. Hard coke may be made artificially from coal that would naturally only produce one of a spongy character, by making it into dust, and washing it with water before burning it into coke.

The cleavage has been produced by lateral pressure taking place in different directions, and at various times during the long period that has elapsed since the strata were deposited, which has caused repeated elevation and depression. Coals obtained in a district which is much faulted or folded, and in the neighbourhood of volcanic action, break into small, and give off less gas, but make better coke than do those found in a district where the geological disturbance has not been great; but the alteration is local.

The relative position of the different kinds of coal in the same seam, whether top, middle, or bottom, has nothing to do with the quality; this depends entirely upon the original structure of the coal and the changes through which it has since passed. For the same reason the position of the coal, whether at a great depth or near the surface (unless so near that air and water have affected it), does not influence its quality. Thin coal, and coal of inferior quality, though found, is not worked at great depths, because it would not pay to do so; the pit therefore is sunk through it and it is left. It does pay to work a thin or inferior coal near the surface if it is in such a position that a ready sale may be obtained on or near the spot.

DEEP MINING. BY W. E. GARFORTH, F.G.S.

The question of working coal at depths varying from two to four thousand feet below the surface was fully investigated in the years 1866-71, by the Royal Commission appointed to enquire into the probable duration of the coal-fields, and the several matters relating to coal in the United Kingdom.

The evidence given before that Commission was most valuable and exhaustive, and the Report, which not only dealt with the state of affairs at that time, but foreshowed many of the circumstances which have since occurred, reflects the highest honour on the distinguished men who formed the several committees. The commissioners estimated the available coal in the known British coalfields (excluding all seams less than 12 inches thick, and after making the necessary deductions for loss in working, faults, &c.) to be 90,297 millions of tons. In addition to such quantity coal is supposed to exist at workable depths under the Permian, New Red Sandstone, and other superincumbent strata, equal to 56,273 millions of tons. The aggregate quantity, which in 1871 was reasonably expected to be available for use, was estimated at 146,480 millions of tons.

Since that report was published an interval of 19 years has elapsed, during which time the quantity of coal raised in the United Kingdom, including the years 1871 and 1889, has been 2,797,344,007 tons.

The following table (with supplementary list for the Yorkshire output) extracted from the Parliamentary Returns shews the quantity raised in the several years :—

YEAR.	Total Tons of Coal raised in the United Kingdom (including Yorkshire).	Tons of Coal raised in Yorkshire.
	TONS.	TONS.
1871	117,439,251	12,801,260
1872	123,393,853	14,576,000
1873	128,544,400	15,311,778
1874	126,590,108	14,827,313
1875	133,306,485	15,855,990
1876	134,125,166	15,129,506
1877	134,179,968	15,805,235
1878	132,612,063	15,582,283
1879	133,720,393	16,241,443
1880	146,969,409	17,468,536
1881	154,184,300	18,287,141
1882	156,499,977	18,525,406
1883	163,737,327	19,563,287
1884	160,757,779	19,220,144
1885	159,351,418	18,497,778
1886	157,518,482	19,389,336
1887	162,119,812	20,104,713
1888	182,660,160	20,576,375
1889	189,633,656	21,973,400
	2,797,344,007	329,736,924

NOTE.—It is a matter for regret that no record is kept of the depths at which the coal shewn in the table has been worked, consequently it is impossible to state the rate at which the average depth is increasing. The depth of the shaft is no criterion, as seams lying at different depths may, by inclines and tunnels, be raised from the same level. It is to be hoped some arrangement will shortly be made to obtain such information. With a return of the area and thickness of the seam worked within certain limits of depth, an approximate tonnage might be given.

The greatest depth of shaft in 1871 was 2,376 feet, as compared with 2,850 feet at the present time. The latter does not however fully represent the greatest depth at which coal is now being worked, as some seams are worken by means of inclines.

Many collieries from which large quantities of coal have been obtained in the past are now exhausted, the shafts closed, and the works abandoned.

The knowledge of the foregoing and other facts suggested the idea that the subject of Deep Mining was one which, after an interval of nearly twenty years, might with advantage be considered by the members of a Scientific Society such as I have now the honour to address.

It has been said that no branch of science contributes to another without receiving a reciprocal benefit. It is therefore hoped that by an interchange of ideas between the geologist, microscopist, mining engineer, and other scientist, some practical suggestions may be offered to colliery officials and miners generally, with a view of lessening the difficulties connected with deep mining, and if possible rendering underground work more endurable.

Improvements which have been made during the last few years in machinery, ropes, and other colliery appliances, especially in electrical work, together with the increased information gained in the method of working seams of coal has already produced a feeling that coal may be worked at a much greater depth than was deemed feasible a few years ago. Much has already been done to bring scientific research into practical shape, and to substitute certainty for uncertainty.

The difficulties connected with deep mining relate however more particularly to natural laws. In discussing the best means of overcoming such obstacles it is well to remember the doubts expressed by the last generation of colliery officials as to working coal at a depth of 400 to 500 yards. Difficulties which at one time seemed insurmountable have since been overcome. Nature does not volunteer information which man may discover for himself, probably for the reason that when man is capable of appreciating it he is capable of discovering it.

No doubt there yet remain certain natural laws to be discovered. In the meantime man must remember that coal has been Divinely stored at great depths, with what intention his finite mind cannot at present comprehend.

Some years ago (1870-73) the high price and scarcity of coal was deemed by certain consumers a national calamity. It is now admitted to have been a national blessing. Consequent on such scarcity several important inventions were introduced whereby a nearer approach to perfect combustion of fuel was obtained, and a permanent reduction and saving obtained in the consumption of coal. From this fact may it not be argued that if coal were situate within easier reach of the surface it might not be preserved and used with the same care as it probably will be in the future, after being raised from depths exceeding one thousand yards.

The question for the future is not: How long will the coal in this country afford a supply? but rather, at what price can coal be raised to enable the manufacturer in this country to successfully compete with foreign productions?

The chief obstacle in working coal at great depths is the increase of temperature which accompanies increase of depth. From observations which have been made, it appears the temperature of the earth is constant at a depth of about 50 feet, and at that depth it is usually 50 degrees Fahr. In 1871 the Commission assumed the rate of increase to be one degree for every 60 feet in depth. Recent observations taken at Ashton Moss Colliery, which is the deepest shaft in England, at a depth of 2,850 feet show the temperature to be 85 degrees. This proves the rate of increase to be one degeee for every 76·9 feet. At another colliery a few miles distant, one degree for every 79 feet. In this district large quantities of water have been found in the strata, which may account for the slowness of the rate of increase shown by the foregoing observations, as compared with that fixed by the Commission. Water cannot be taken as a guide to temperature as it may come from above or below. It has been hoped future deep sinkings might prove the increase of temperature to be in a diminishing ratio; but when the primary cause which has led to the increase already proved, is considered, it is hardly reasonable to expect such will be the case. High temperature of the strata operates as an impediment to deep working by heating the air circulating through the passages of the mine. This heating process is most rapid at first when the difference of temperature between the air and the strata is greatest, gradually diminishing as the length of the passage is extended, and never ceasing until complete assimilation is effected. The progress towards this assimilation is much more rapid when the air comes in contact with a large area of freshly wrought coal at long long distances from the shaft. When a large volume of fresh air is passing through the mine, it is considerably influenced in lowering the temperature, but at long distances in-bye, and where coal roads exist, the cooling effect of the ventilation is small. As the air in circulation is gradually increased, so the temperature of the strata is reduced by the absorption of heat from it. Evidence was given before the Commission of the temperature endured in the stoke-holes of steamers, and places where glassblowers work. In some cases labour had been carried on where the thermometer indicated 180 degrees, but in such cases it was radiated heat and did not accurately indicate the temperature. It was also proved by the experience obtained in foreign climates that a temperature of 125 degrees in the shade was more endurable by reason of the dryness of the air than moist air of 86 degrees. In certain cotton mills the temperature often exceeds 90 degrees, and in this atmosphere some operatives are engaged for ten consecutive hours. The depth stated by the Commission at which the temperature of the air would amount to 98 degrees, or blood-heat, was about 3,000 feet. From experiments conducted by medical men and scientists it has been shown that at a temperature of 84 degrees Fahr. workmen are not inconvenienced, and can continue their occupation for years without interruption. Complaints of languor are, however, made. From 100 to 110 degrees this feeling is increased, and manifests itself in diminished muscular power, resulting finally in further muscular disturbance and paralysis of the heart. It has also been proved by experiment that man's skin is better adapted and can withstand a greater heat than certain animals. This is due to increased respiration, circulation, and evaporation, by which the body is prevented from rising above the natural temperature. If a man's body could not lose by evaporation, &c., the heat which may be produced within him it would intensify and result in death.

As regards increased barometric pressure, some men are capable of bearing a pressure of 38 or 40 inches of mercury without serious results, and medical men are of opinion that increased pressure is not likely to reduce the power of enduring increased temperature, or that it will affect evaporation.

The conclusion arrived at by the Commission was "That the increase of temperature and depth was so speculative that they felt it better to leave the question in uncertainty, but looking to possible expedients which the future may elicit for further reducing the temperature, they considered it might be fairly assumed that the depth of at least 4,000 feet might be reached."

In addition to the difficulties of increased temperature there is also the difficulty of maintaining the roadways consequent on the increased weight of the superincumbent strata. If the coal when *in situ* gives support to the overlying strata, that is by a square foot supporting a corresponding foot, it will be understood that when a portion of the coal is extracted, a weight over and above the natural one is thrown on the remaining pillars. This difficulty has, of course, been experienced in working shallow mines, but in deep mining the greater the thickness of the superincumbent strata necessarily the greater the weight and cost of maintaining the roads for the conveyance of material, but especially for the purposes of ventilation. Experience has shown that no system of working can reduce the weight of the superincumbent strata, and the methods which necessitate pillars of coal being left, even for a short time, cannot at greater depths be worked with advantage. To meet this difficulty mines have been for many years worked on the longwall system, that is, by removing the coal at one operation. This system was well-known and practised in Scotland, the Midland Coalfields, and at certain collieries in other counties, many years previous to 1871. But it was not as generally well-known nor practised in Lancashire and Cheshire, where the deepest mines have been worked, as it is at the present day.

With reference to certain mechanical and other appliances which will be required for raising large quanties of coal up a deep vertical shaft or long incline, within a given time, or passing large volumes of air at an increased temperature to dilute noxious gases and for the purpose of ventilation, or for lighting roadways and working places at long distances from the shaft, or for haulage and other purposes, I venture to think there will be no difficulty. Other works and manufactories have already some of the appliances which may with few modifications be adapted with advantage to collieries.

Within the last few years several mines have been opened out between two and three thousand feet deep, and it may therefore assist in the consideration of this matter to state what has been actually proved.

At Ashton Moss on a level with the shaft bottom (viz. 2850 feet) or down the incline at a depth from the surface of 3036 feet the temperature varies from 85 to 87 degrees. The air is dry at the coal face, and the moisture which was expected would be given off and prove an obstacle, has not proved to be the case. The workmen up to the present have worked about the same length of time as those employed in the shallower pits, say 7 to 8 hours, without suffering any serious inconvenience. No complaints have been made that the high temperature has affected their health. There is no difficulty in obtaining labour. The men drink large quantities of cold tea, coffee, or water, and appear quite as healthy as men working in other pits, though it must be admitted they cannot work with the same energy and vigour which is a characteristic in the shallower pits. Fortunately the same physical force is not required, as the superincumbent weight acting upon the coal renders it easier to get.

The men do not appear to be affected by increased barometric pressure equal to 3¼ inches of mercury over and above that on the surface. This pressure is a trifle compared with that withstood by sinkers in working the pneumatic process.

The quality of the coal now being worked at great depths is admitted to be quite equal to the most valuable seams hitherto worked, indeed deep seams are, generally speaking, superior to mines lying nearer the surface. No water has been met with except a few drops with a saline taste. The quantity of gas given off from the mine is no greater than in shallow mines. Some mines which might be mentioned lying at one third the depth give off a greater quantity of gas than the deep mines referred to.

No difficulty has up to the present been experienced in ventilating the mine. The strata being inclined the ventilation is conducted on the ascentional principle by means of a furnace. Owing to the long motive column a large volume of air is circulated through the mine at a less cost than any other mine that can be mentioned. From the foregoing it will be inferred that the difficulties actually proved in working the mines at Ashton Moss are less than anticipated by the Royal Commission. In addition to the improvements which have been introduced during the last few years in coal mines, it is probable some of the following suggestions may in the future be found advantageous in working deep coal. With a view of reducing the friction and preventing an increase of temperature from the causes referred to, the upcast and downcast shafts should be sunk a considerable distance from each other instead of, as at present, close together. There are of course objections to this arrangement amongst others, the extra length of time required to form a communication between the shafts, and the difficulty of driving and maintaining the roadways. With reference to the former, the extra length of time required to form a communication is not a serious one when compared with the permanent advantages of reduced friction of air, &c. As regards the latter, it has been proved at a depth of 1000 yards, that a width of, from 40 to 100 yards, is sufficient to allow the superincumbent strata to break and thus relieve itself. In this width roadways can be formed of débris which after a time becomes so consolidated that they are better for ventilating purposes than pillars of crushed coal. Pack roadways do not give off gas or heat like the natural sides of coal, so that when the temperature of the dirt roadway is reduced it is possible the heat of the mine will be the same at long distances in-bye as it is at the bottom of the shaft. To prevent the natural temperature of the air, being increased by the use of lamps, &c., or vitiated by the employment of horses, electric lamps will be used for lighting the mine, and electric motors for haulage, and probably for getting the coal.

If electric motors can be used and worked without sparking (which is such a serious objection at the present time) it is also likely small fans will be introduced at the coal face to promote a temporary increased circulation of air, in the same way as the Punkah is used in India and other hot climates. This arrangement could be carried out without interfering with the general ventilation of the mine.

To further reduce the temperature it would be quite practicable to have troughs of water at the sides of the roadways. On the principle that warm air absorbs more moisture than cold. the air might thus be reduced without being too heavily charged with moisture.

Other matters connected with the cost of production, waste in working, structural formation of coal, dirt and other strata, the further application of electricity, the absorption of heat by different substances, certain mechanical and chemical appliances for reducing the temperature, etcetra, it is hoped will be dealt with in the after discussion.

Looking at the question from a mining point of view, and after an experience of nearly twenty years in the deepest mines, I believe coal will be worked as deep as it will be found to exist. In arriving at this opinion I have, amongst other matters, considered the fact that the thickness and quality of the deepest coal already proved is not thin, faulty, or inferior (which might have led to certain doubts being entertained), but on the contrary the deep seams are four to six feet thick, and equal in quality to the best coal hitherto produced. With reference to labour there has been for some time past a reduction in the number of accidents in proportion to the quantity of material raised, due no doubt to parliamentary legislation, better education, and stricter discipline, from which it may be assumed that deep coal will, in the future, be won without greater loss of life than in the past.

ON LEPIDOPHLOIOS AND LEPIDODENDRON.

BY WM. CASH, F.G.S., F.L.S., F.R.M.S., AND JAS. LOMAX.

The genus *Lepidophloios* appears to have been established by Sternberg at a time when our knowledge of Carboniferous plants was based, for the most part, upon merely superficial characters and not upon the anatomical structure of the plants themselves. The two genera, *Lepidodendron* and *Lepidophloios*, though long known to hold close affinities, are clearly separated by well-marked characters.

In *Lepidodendron* the leaf-cushions are fusiform or quadrate, varying much in form, even in the same species, according to their position on the stem and conditions of growth. Situated on the cushions and generally above the centre is the leaf-scar proper, whose upper and lower boundary lines are usually more or less convex and unite in lateral angles. Within the leaf-scar are three punctiform cicatricules, the central of which is alone connected with the vascular system, the two lateral being probably glandular. The cones in some species are borne at the terminations of the branches, and in others in two opposite vertical rows (Ulodendron, L. and H., *in part*).

In *Lepidophloios* the leaf-cushions are rhomboidal (as in *L. laricinum*) or elongated-truncate (as in *L. scoticum*), and the leaf-scar is situated at the extremity of the cushion, having three punctiform cicatricules as in *Lepidodendron.* The cones are borne on specially modified branches and are arranged in spirals (*Halonia,* L. and H.)

The two genera are therefore very distinct in the position of the leaf-scar on the cushion, as also in the mode of fructification. The knowledge obtained of the structure of *Lepidophloios* since Sternberg's time, and especially that acquired in recent years, has confirmed the view of its close affinity with *Lepidodendron.*

Williamson has described the twigs, branches, stems, and fruits of *Lepidophloios brevifolium* from Burntisland, and has shown that, fundamentally, these have the structure of the same parts of *Lepidodendron*.

Solms-Laubach, in his 'Einleitung in die Palæphytologie,' states that Corda's *Lomatophloios crassicaule* has a structure similar to that of the true *Lepidodendron Harcourtii.*

Inasmuch, however, as Corda's genus *Lomatophloios* is Sternberg's *Lepidophloios,* there is sufficient justification for his conclusion that the structure of *Lepidodendron Harcourtii* may occur in *Lepidophloios.*

Further, the same authority states that the plant described by Williamson as *Lepidophloios brevifolium* is intermediate in structure between *Lepidodendron Harcourtii* and *Lepidodendron vasculare,* Binney (*L. selaginoides,* Carr and Will.) Its primary xylem has *not* the crenulated outline of the former species, though its structure is the same, but its leaf-trace bundles run downwards with only a slight projection, as in the latter. It further agrees, he adds, with the latter in the massive development of its secondary xylem. To these proofs of the near relation of the two genera under consideration, we are in a position to add yet another, drawn from a specimen which we discovered some short time ago. This consists of a fossil stem whose external surface is marked by tolerably well-preserved characters, which leave no doubt that it must be referred to the genus *Lepidophloios* as defined by Sternberg.

Transverse sections of it show, however, that in internal structure it is identical with the plant described by Williamson in his XIth memoir as *Lepidodendron Harcourtii,* but since named by him *Lepidodendron fuliginosum.*

The primary xylem has an outer periphery *slightly* crenulated, is in the form of a thin, hollow cylinder, and encloses a tolerably large pith composed of thin-walled parenchyma. Surrounding the primary xylem is a zone of dark, indistinct tissue in which are radially disposed elements, and which Williamson regards as the exogenous zone (secondary xylem) in an immature condition. Outside this is the thick cortex, which, in its general appearance as well as in the structure and the arrangement of several layers, is in close agreement with that of *Lepidodendron fuliginosum.**

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* Communicated to the Meeting of the British Association, 1890.

ON THE SO-CALLED INGLETON GRANITE. BY THOMAS TATE, F.G.S.

Under this commercial name a rock has recently been brought into the market for road metal. It is quarried in the Borrowdale Series underlying the Mountain Limestone forming Twistleton Scars on the north-west, near to Dale Barn, and Raven Scars on the south-east; extending thus quite across the Dale above Ingleton, having a thickness of about 400 yards, with a sharp dip to the south-west.

This rock has given rise to much discussion locally, as to its origin. It has been variously described in published records as a conglomerate, a trap, a felspathic ash, and as a metamorphic slate.

As to the texture of the rock, no one of its components is conspicuously larger than the average of its fellows; each layer exhibits a uniform grain, but the layers graduate from about one-eight of an inch down to the finest granules. This marked uniformity along successive planes points to the sorting action of gravity exerted upon materials held in aqueous suspension. Sedimentation is further in evidence by the parallelism of all the longer axes and the stratification arising therefrom. Beneath the microscope most of the ingredients are seen to be sharply angular, nevertheless a fair proportion are well-rounded and water-worn.

The detritus of a quartzite has supplied many of the clastic elements. Next to this come crystals of quartz and felspars, both orthoclase and plagioclase, the latter being the more abundant, relatively, in the finer-grained layers. Ancient lavas, both acidic and basic, devitrified sphærulitic rhyolites, augite, andesites, and deep-seated micropegmatite have contributed of their spoils.

These detrital products, enclosed in a volcanic ash matrix of a diabasic character, have consolidated into a tough rock of low-specific gravity (2·693), and possessing great tenacity.

With the exception of a few strain-shadows along the margins of quartz grains, the micro-slides offer no suggestions of the ingredients having suffered from mechanical deformation. In the quarry, however, may be noticed one or two quite local examples of schistosity resulting from shearing, in close proximity to shrinkage joints, now infilled with quartz and a green earthy degradation product.

Above and below this rock shades off conformably into grey-green indurated ash-beds, a layer of which also occurs in the middle of the rock in the quarry. Flakes and lenticular fragments of volcanic mud, scooped off the old sea-floor, have been caught up in the superposed volcanic ash matrix, near to the line of junction, and some of these entangled patches when freshly exposed in the quarry show internally a septarian arrangement, the outer portions flaking off along faces coated with a lustrous film ; the inner surface subsequently weathering to a variegated dull purple or brownish tint.

The quarry in Chapel-le-Dale may be inspected on the way to or from Ingleborough.[*]

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[*] Read before Section C (Geology) British Association Meeting, held at Leeds, 1890.

PHYSICAL HISTORY OF THE CARBONIFEROUS ROCKS IN UPPER AIRE-DALE.

BY R. H. TIDDEMAN, M.A., F.G.S., OF THE GEOLOGICAL SURVEY.

During the last few years the rocks in this area have been mapped in considerable detail by the Geological Survey, and the results which are coming out seem likely to throw much light upon the physiography of Carboniferous seas and perhaps upon the genesis of some limestones of other ages.

It was always a puzzle to those geologists who knew the ground how it came to pass that the well-known and very persistent series of the several limestones of the Yoredale Beds ran with such regularity over the great area of the Yorkshire dales and yet were not recognizable over the area of Bowland and the southern part of Craven.

Until the area of which we now speak was carefully surveyed, it was assumed that there was a rapid transition of type in the Carboniferous Rocks between Clitheroe and the big fells north of Settle and Malham, but as to the cause of such a rapid change no explanation was forthcoming. Even Professor Phillips, who knew the country perhaps best of any among the old pioneers of Geology, often expressed himself to me as quite unable to account for it. If there is one thing more clearly brought out than another by the mapping in detail of this ground, it is this, that there is absolutely no transition from one type to the other. The two types run unchanged in their respective areas and with complete discordance with each other, quite up to a common boundary where the differences are rather accentuated than smoothed down. They might be Jews and Samaritans, agreeing in nothing save a common boundary to their territories and a determination to have nothing to do with one another.

The line of demarcation is given by the Craven Faults, and more particularly by that which runs by the south end of Malham Tarn and that which passes between Malham Cove and Malham.

With these preliminary remarks we may introduce a table showing the rocks in the two areas and their principal divisions and thicknesses.

TABLE OF THE CARBONIFEROUS ROCKS IN CRAVEN.

Southern or Bowland Type.	Feet.		Feet.	Northern or Yoredale Type.	
COAL MEASURES (Ingleton)	1,500	The great Craven faults.	...	COAL MEASURES	Incomplete near the faults in this area.
MILLSTONE GRITS	3,900		..	MILLSTONE GRITS	
BOWLAND SHALES	300,-1,000		400—900	YOREDALE SERIES	
PENDLESIDE GRITS (inconstant)	0 - 250				
PENDLESIDE LIMESTONE (with Knoll-Reefs)	0—400				
SHALES, with Limestones	2,500		400—800	THE CARBONIFEROUS LIMESTONE (with conglomerates at base).	
CLITHEROE LIMESTONES (with Knoll-Reefs)	×3,250 No base.				

The rocks on both sides of these faults seem to have been formed on slowly subsiding areas, but the Bowland area appears to have been subsiding more quickly and to a greater extent than the area occupied by the Yoredale type. It represents the downthrow side of the faults. The other side of the faults of course is relatively an upthrow.

The question next arises: When did these earth-movements take place?

We know that some of the movements have occurred since the deposition of the Permian rocks, because these have in places, near as Ingleton, been tilted up at high angles thereby; but we also know that a far greater part of them were going on before the Permian rocks were deposited, because these lie at different places by unconformity on all the members of the Carboniferous—a series which shows near Burnley a vertical thickness of three miles of rocks without base or completed top. The movements necessary to subject so great a thickness of rocks to denudation in all its members before the advent of the Permian epoch must have been enormous. We may, therefore, well believe, and indeed can hardly doubt, that the crust was subjected to great movements during Carboniferous times.

When further we consider how great is the discrepancy between the rocks of the two areas in series and in thickness—that the Craven Faults form the boundary, and that a sharp one, between them—that these two series proceed from that boundary with scarcely any change, one as far as the Tyne, and the other to the western limit of the Carboniferous Rocks or the seaside plain of Lancashire—that the greater thickness is on the downthrow side of the faults—if we take all these points, I say, into consideration, it is impossible to come to any other conclusion than this :—

That the Craven Faults were to a very considerable extent going on during the formation of these rocks and that they are responsible for the lack of agreement between the two series which were being simultaneously deposited in the two adjacent areas.

This appears at first sight to be a rather large subject to be introduced into a description of the small valley of the Upper Aire, but it so happens that it was this valley in the neighbourhood of Malham together with the adjacent country on either side, along the faults westwards to the Ribble and eastwards to the Wharfe, which gave the key to unlock the mystery to which I have alluded. I had long suspected that these faults had been at work in Carboniferous times, but until this particular piece of ground lately fell to my lot to map, the actual demonstration was wanting. I then not only found my suspicions confirmed, but the uncompromising nature of the two adjacent types set forth in a manner most unmistakeable.

If we are driven to the conclusion that the movements of the Craven faults and the consequent alterations of conditions of deposit were the causes of the two distinct series in the areas north and south of the faults, several interesting questions arise. We may expect that on the downthrow side we shall get a series of deposits of which a greater portion has been formed under deeper water conditions than we shall find on the upthrow, or rather lesser downthrow, side.

Though doubtless the movements proceeded by fits and starts, and were not always at uniform rates, still there will be a greater number of beds representing shallow than deep water conditions.

If we can ascertain which beds are which, we shall be able to get a juster notion of the relative rate, duration and extent in depth of the several successive movements which combined have brought about the final results. *Relative* only, for so far we have no positive scale to give us either the rate of the earth movements or of the formation of the deposits whose character was dependent on them.

There is in the first place much presumptive evidence to be gained by consulting the Table of Rocks by any one who has a little personal knowledge of them. For instance, let us take (on the shallow side) the Carboniferous Limestone, 400 ft. It is nearly all a whitish or light crystalline limestone. Shales are seldom seen in it or are very thin. On the deeper side this is represented by Pendleside Limestone 0—400 ft., Shales with Limestone 2,500 ft., Clitheroe Limestone 3,250 ft. Of these three the first is very variable in thickness and sometimes absent; the second consists much more of shale than limestone, and its contained limestones are often, in fact usually, very impure, besides being untraceable for any distance; and the third, the Clitheroe Limestone, includes great thicknesses of shale. Then to go higher. The Yoredale Series on the shallow side contains many beds of pure limestone, persistent for the most part throughout the area. The Bowland shales on the deeper side contain no limestones at all.

What is the general result to be gleaned here? This: that in the shallower waters the limestones predominate, in the deeper waters the shales and mud.

But we must be cautious; all limestones are not shallow-water deposits; all muds are not deposited in deep waters. There are differences in limestones, and we are enabled to determine that some of them are of shallow water formation and others probably made at greater depth.

There are two very distinct kinds of limestone in the country on the downthrow side of the faults, the black, or blue as it is often called, and the white or light coloured limestone. They are not only distinct in lithological character but in bedding and general arrangement, as well as in their form in the mass, and the character which they give to the landscape. The black limestone is always well, evenly, and usually thinly bedded, and contains shaley partings.

The strike, except in a contorted country, is generally very regular and continuous. On minute examination this rock is found to be full of Foraminifera, and fragments of other organisms in a state of disintegration, though perfect fossils of certain kinds frequently occur in it. It would be called by a geologist a distinctly well stratified rock; it gives good regular features along its strike, and extends over wide areas.

The white limestones south of the faults, on the other hand, are notable for their comparatively massive character and irregular bedding. They occur sporadically, rising into big mounds of conical form which usually rest on the black limestones. They contain great quantities of Cephalopods, Brachiopods, Lamellibranchs, Gasteropods, Corals, etc., and these are often in a wonderfully perfect state, and, from the way in which they compose the rock, appear to have lived and died on the spot.

The general structure of these big mounds, or Knoll-Reefs, as I have called them, is very peculiar. They do not obey the rules of dip and strike which are usually found to obtain in ordinary parallel-bedded deposits, and any one seeking to apply these rules to them in mapping will be landed in numerous puzzles and difficulties. When, however, from the examination of several of them, the general structure is once mastered, their peculiar forms soon become easy of comprehension. Where they are quite perfect, a condition in which weathering has seldom left them, they are seen to consist of a flat top, the dip of which usually agrees with that of the other rocks of the country around in every direction and angle of dip, and steep sides all round, the dip of which is away from the centre of the hill. This dip averages 30° to 35°, but may be much higher or lower, in proportion as the dip of these flanking beds is increased or lessened by the general dip of the country round. The dip of the flat at the top is a plane of deposition, which was once horizontal. The dip of the flanking beds represents on the other hand an *original angle of deposit*, plus or minus any subsequent tilting by movements of the crust.

In other Knoll-Reefs, which have been cut into by weathering or quarrying, we find that the beds within, though sometimes obscure, present the usual dip of the country, but following them outwards we find them running into, and continuous with, the flanking beds.

It is pretty obvious from their structure that the internal beds represent successive layers, limited in their area, of growths of organisms, and that they pass into steeply-shelving banks of similar *débris* lying on the flanks of the knoll at an angle of rest. The study of the fossils composing these respective beds quite confirms this idea.

From these and other considerations, which would be too long to enter into here, there can be very little doubt that the mounds, or knoll-reefs, have been formed in a similar way to coral reefs, by growth upwards under favourable conditions of the animals of which they are composed, and by the piling up by waves, perhaps also in some places by winds, of the resulting débris. This has no doubt been going on upon a slowly sinking area, and it is a remarkable fact that none of these mounds so far have been found except on the sinking area on the downthrow side of the Craven Faults.

It is evident from facts collected in this area that large portions of those reefs, if not all successively, have been exposed to the wash of the waves between wind and water, as is the case with coral-reefs. Breccias composed of fragments of limestone, mostly sharply angular, some more rounded, and others, less frequently, worn into pebbles, have been found abundantly in many places. In some cases the breccia forms part of the inner beds of the reef; in others it is well developed in the flanking beds; and elsewhere we find beds of breccia formed on the sea bottom adjoining the reef, and inter-bedded with the lowest beds of shale accumulated on the sea bed from which the knoll has grown up.

Here then we have good evidence of these white limestones having been formed in shallow water, so shallow that the breakers could play upon, break up, and re-arrange them on the shore platform above, or consign them to deep water below.

Furthermore, some of the white limestones in certain places present phenomena which suggest that they have been formed, or rather re-constructed from calcareous débris, by wind-drifting, or have at any rate been consolidated in the open air, but as this matter is still under examination, I must postpone any further remarks on this part of my subject.

Although the white limestones, from their sporadic distribution, their physical structure, and their material, are evidently, if not coral-reefs, something formed in a kindred way, the black limestones show marked contrast to them in every way, and evidently have had a totally different origin. Most of these black limestones, which to the eye appear to be structureless, are found, when sliced and examined by the microscope, to be to a very large extent made up of Foraminifera and fragments of other organisms in a state of minute disintegration. Not that there is altogether a lack of larger and more perfect specimens, but these are not nearly so abundant as in the white limestones. Then the strongly marked bedding, so regular and parallel, the frequent alternations with thin beds of shale, and the wide and uninterrupted spread of these deposits, are all suggestive of deposition in waters which were not shallow, and in which similar conditions prevailed over wide areas.

Without going further into the evidence here, we may say that it is highly probable that the black limestones are successive floors of the ocean bed of Carboniferous times, and that the white limestones are the islands which dotted its surface.

These conclusions are derived from minute examination of a wide area, and it now remains to apply them to a part of it, the Upper Aire Valley. The portion of the Aire Basin which I propose to allude to is that N. and N.E. from Skipton, containing the head waters of the Aire from Malham Tarn downwards and its tributaries, Winterburn Beck, Flasby Beck, Linton Beck, and Skipton Brook.

If we take these areas in order from the South, as seen in one-inch maps, 60 and 61 (New Series) of the Geological Survey, we shall find that, after leaving that portion of the valley which cuts the Millstone Grit Series with its escarpments, we have (1) a great anticline which runs E.N.E. and W.S.W. from Skipton, passing by or near Bolton Abbey; next (2) a syncline of which the centre lies near Gargrave, and which brings down in its fold the Millstone Grits along a line from Flasby Fell, or Sharp Haw (pronounced Sharpa), to the Wharfe at Bolton Strid. (3) North of this comes another anticline, marked by the limestones running from near Otterburn to Grassington, also on the Wharfe. (4) A lesser anticline runs out from this, budding off as it were from it on the North, near Airton, and this is succeeded by (5) A small syncline lying just south of the village of Malham.

We have already stated that the white limestones are only sporadic in their distribution. We may also state that they occur on at least two, and probably more horizons. Referring to the Table of Rocks, we may say that they occur both in the Clitheroe Limestone and in the Pendleside Limestone. They are far more abundantly distributed on the former horizon in the Clitheroe District than in this northern part. On the other hand they are commoner in this part on the horizon of the Pendleside limestone than on any other.

The great anticline of limestone so much worked near the Leeds and Liverpool Canal to the north east of Skipton at Haw Park and Skibeden is mostly of black limestone. It is probably of the same horizon as the Bold Venture Quarries at Chatburn, and certainly belongs to the Clitheroe set of Limestones.

The big patch of limestone extending from Otterburn by Winterburn and Hetton to Rylstone, is on the Clitheroe horizon, and is all of the black limestone, except a small patch on its surface at Haw Crag Quarry, above Bell Busk, where the limestone has a decided reef character, and perhaps also on the hill east of Winterburn, but this is more doubtful. This anticlinal area of limestone shows a thickness of upwards of 2,000 ft. without a base.

Limestones of reef character also occur near Pot House and Holmes Gill Green, but they are much disturbed, and cannot be regarded as typical examples of reef-knolls.

The Pendleside Limestone is separated from the Clitheroe Limestone below by a thickness of 2,000 or 2,500 feet of shales with impure limestones and mudstones, which may be seen in the Winterburn Valley, in the Aire Valley from Newfield quarry to and beyond Kirby Malham, east of Rylstone, and in other places.

The great interest attaching to them lies in their approaching with this thickness so near to the faults in this area, though entirely absent to the north of them. The range of the Pendleside Limestone may be followed on the maps without much difficulty. It crosses the Aire Valley between Kirby Malham and Malham. A good section of it with beds of reef character may be seen on the east side of the stream here.

A little further south and on to Calton it is much contorted and also faulted. From this village eastwards it is much concealed by drift, but shows again with sections of great interest at the Winterburn Reservoir. Here we have black, well-bedded limestone surmounted by white reef limestone with little bedding, but the upper sloping surface of it as seen, or lately seen, in the dam of the puddle trench, consists of a close breccia of angular fragments of limestone. The Bowland Shales in Calfgill (or Way gill, one-inch map) hard by, are full of beds containing fragments and pebbles of limestone, and even large detached boulders are found in them. These interesting sections will unfortunately be drowned in the waters of the Reservoir.

To the East this limestone is only obscurely shown for some distance, but it swells out again into bigger dimensions at the great long knoll of Swinden, and on the other side of a peaty swamp, containing a trough of Bowland Shales, is conspicuous in a wonderful assemblage of knolls, bearing the names of Skelterton, Carden, Butterhaw, Stebden, Elbolton, and many others, running by Burnsall to the Wharfe. Elbolton and Stebden are extremely fine and conspicuous examples, Stebden in particular rising high towards the Grit Fells, and showing well the quaquaversal dip of its flanking beds. Skelterton appears rather to exhibit a section of the internal economy of a knoll, showing great stools of coral running in beds, the interspaces being filled up with crinoidal remains.

As we trace these beds away on the south side of the anticline they lessen much in feature and thickness, so much so that we cannot follow them with certainty beyond Flasby. On the north side of the Skipton anticline, however, they come in on the same horizon, and may be traced for some miles, exhibiting in places a decidedly brecciated character.

The well-known Draughton Limestone on the south side of that anticline, so popular as an instance of a contorted limestone, is seen on weathered surfaces to be made up of breccia in some of its beds, a fact which I believe has hitherto escaped notice. This is well seen also in a quarry close to the right side of the road, where there is a limekiln, on the way from Skipton, just before getting to Draughton.

The general arrangement of the Pendleside Limestone in this area is a dark, well-bedded limestone below, with white crystalline limestone above ; where thin, the latter often consists of a breccia, but where thick, it grows into great knolls ; and these appear to increase in size, and frequency in proximity to the Craven Fault.

We started to follow the range of the Pendleside Limestone in the Aire valley, between Malham and Kirby Malham. To resume it there :—we find that it dips to the north and disappears beneath the Bowland Shales, which are seen in several places, but this is only for a short distance, for it rises quickly again and forms those two great knolls between which the village of Malham snugly nestles. Then comes the fault, not very clearly seen in the river course, then Malham Cove, and further east Gordale Scar, two of the grandest features of the district.

Breccias of fragments of limestone occur in the lower part of the Bowland Shales in ascending Tranlands Beck where the first little stream joins it from the north, and still better are they seen higher up the same little gill, near the " M " of Malham on the one-inch map, close to " Heads Barn."

Further to the south and west good exposures of these beds may be studied in the gill a few hundred yards above Pott House, and a greater thickness in Newton Gill about a mile east of Long Preston. East of Malham we have already alluded to breccias at Winterburn Reservoir. They occur also between Carden and Elbolton Knolls, and in two or three places beyond the village of Thorpe in the Wharfe valley. At these localities they are all in Bowland Shales.

If we ascend to the top of the crags above Malham Cove, we soon find ourselves upon the great plateau of the Mountain Limestone proper. This, though broken at the foot of Malham Tarn, by the North Craven Fault, which throws up its base, and shows us how thin it is, and crossed by many minor faults, is one and the same as the great spread of Mountain Limestone which lies beneath all the Yorkshire dales and extends north to beyond the Tyne valley. We have crossed the Fault, and in so doing have exchanged the Clitheroe or Bowland series for the Yoredale type, and if we could realise the state of affairs when these rocks were forming, we should probably say that we had left a deep sea dotted with islands and come on to a wide and long and shallow reef.

The long history of that reef and its denizens from its early foundation on a slowly sinking plateau of slate rocks, to its last phase when the animals which lived on it, and formed it, had to succumb to conditions fatal to their existence, the recurrence oft-repeated of favouring or fatal environments, the movements of submergance and emergence connected therewith, the set of tides and currents, the transport of material, these and many other matters may be read in the Mountain Limestone and Yoredale Series, but as yet they are written only in the rocks.

SECRETARY'S REPORT.

During the past year the Society has lost six members by death. Sir Edward Baines, William Aldam, J.P., Edward Hailstone, F.S.A., Samuel Taylor Rigge, F.S.A., Edward Harding, and Samuel A. Adamson, F.G.S.

Mr. Adamson was the Local Secretary of this Society for the Leeds district, and in a many ways the Society has been indebted to his disinterested energy. His early death, at the age of 43, left his wife and four children nearly unprovided for; and at the instance of your Honorary Secretary a meeting of representatives of this and other Societies with which he had been more or less intimately associated was held, with the result that it was decided to appeal for funds to form a Memorial to Mr. Adamson, which should be employed for the benefit of his widow and family. At the present time about £175 has been subscribed.

The Annual General Meeting was held in the Lecture Theatre of the Literary and Philosophical Society, Halifax, on Wednesday, 5th of November, 1890. Mr. Alderman James Booth, Mayor of Halifax and a Vice-President of the Society, occupied the chair, and the following papers were read :—

W. E. Garforth, J.P., F.G.S., &c., "On Mining at 100 yards and deeper."

G. R. Vine, "Notes on the Polyzoa and Microzoa of the Red Chalk of Yorkshire and Norfolk."

C. E. De Rance, Assoc. Inst. C.E., F.G.S., F.R.G.S., Secretary of the Underground Water Committee of the British Association, "Notes on Borings for Water and Salt in Yorkshire."

Rev. E. Maule Cole, M.A., &c., "On the Opening of the Great Tumulus at Duggleby."

Thomas Tate, F.G.S., "On the so-called Ingleton Granite."

J. R. Mortimer, "On the Pre-history of Fimber."

J. R. Mortimer, "On the supposed Roman Camp at Octon, near Bridlington."

G. W. Lamplugh, "On the Erratic Boulders of the Yorkshire Coast."

A. W. Harker, M.A., F.G.S., "Petrological Notes on the Boulders of Flamborough Head."

J. R. Dakyns, F.G.S. of H.M. Geological Survey, "On the Changes of the Lower Carboniferous Rocks in Yorkshire from South to North."

B. Holgate, F.G.S., "On Some Physical Properties of Coal."

B. Holgate, F.G.S., "On the mode of Deposition and Properties of the Carboniferous Strata of Leeds and District."

William Cash, F.G.S., &c., and James Lomax, "On the Structure of Lepidophloios."

The meeting of the British Association for the Advancement of Science has been held this year at Leeds, and the members of this Society have taken much interest in its proceedings. A large and varied series of scientific papers were contributed to the sections by its members, and the interest attached to the meeting was enhanced by the services they rendered at the excursions. On Saturday, September 6th, a special train was run to Bridlington to enable members of the Association to visit Flamborough Head and Speeton, Mr. G. W. Lamplough taking charge of the Speeton section and Mr. James W. Davis guiding the party to Flamborough. Mr. R. H. Tiddeman, F.G.S., of H.M. Geological Survey, and the Rev. Edward Jones, President of the Craven Naturalists' Association, conducted a party to Skipton, Craven, and Thorp, and the opportunity was taken to visit the Elbolton Cave, which is in process of exploration.

On the following Thursday a large party, under the guidance of Mr. J. E. Bedford, F.G.S., and the Rev. E. Maule Cole, M.A., F.G.S., visited Clapham, Ingleborough, and Norber; and on the same day a party, organised by the Yorkshire Naturalists' Union, spent the day at Malham and Gordale. The geological section of the members was conducted by Mr. R. H. Tiddeman and Mr. James W. Davis. A party visited Scarborough and Middlesborough, guided by Mr. J. W. Woodall, M.A., F.G.S., of Scarborough; Mr. T. W. Tew, J.P., conducted a party at Pontefract; and Mr. W. Horne, F.G.S., had charge of a company of members through Wensleydale. Mr. Richard Reynolds officiated in a similar capacity at Beverley, and Mr. Edmund Wilson was the leader of a party of nearly one hundred to Coxwold, Byland and Rievaulx Abbey and to Helmsley.

As in previous years it is with pleasure that the indebtedness of the Society is expressed to those gentlemen who have acted as Local Secretaries. The following is a list of the Local Secretaries together with the districts which they represent : —

Barnsley	T. W. H. Mitchell, Barnsley.
Bradford	Thos. Tate, F.G.S., 5, Eldon Mount, Leeds.
Bridlington	G. W. Lamplugh, Bridlington Quay.
Driffield	Rev. E. Maule Cole, M A , Wetwang, near York.
Halifax	Geo. Patchett, Junr., Halifax.
Harrogate	R. Peach, Harrogate.
Huddersfield	P. Sykes, 33, Estate Buildings, Huddersfield.
Leeds	
Leyburn and Wensleydale	William Horne, F.G.S., Leyburn.
Thirsk	W. Gregson, Baldersby, Thirsk.
York	W. M. Platnauer, The Museum, York.

This Society exchanges its proceedings for those of the Societies whose names are appended. The thanks of the Society are hereby tendered to those Societies for their respective contributions.

Essex Naturalists' Field Club.
Norwich Geological Society.
Memorias de la Sociedad Cientifica "Antonio Alzate," Mexico.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania, Van Dieman's Land.
Royal Dublin Society.
Royal Academy of Science, Stockholm, Sweden.
Geological Association, Liverpool.
Royal Historical and Archæological Association of Ireland.
Geologists' Association, London.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
Midland Naturalist, Birmingham.
Academy of Natural Sciences, Philadelphia, U.S.A.
Naturhistorischen Hofmuseum, Wien, Austria.
Societie Imperiale des Naturalistes, Moscow.
United States Geological Survey of the Territories, Washington.
Boston Society of Natural History, U.S. America.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis, U.S. America.

Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway, Christiana.
Sociètè-Geologique du Nord, Lille.
Royal Society of Edinburgh.
Royal Geological Society of Cornwall.
Geological Society of Edinburgh.
Royal Physical Society of Edinburgh.
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club.
Birmingham Natural History and Microscopical Society.
Bristol Naturalists' Society
Leeds Geological Association
Patent Office Library, London
Powis Land Naturalists' Club, Aberystwith
American Philosophical Society, Philadelphia, U.S.A.
Comité Geologique de Russie, St. Petersburg
Elisha Mitchell Scientific Society, Chapel Hill, U.S. America
Elliott Society of Science and Art, Charleston, U.S.A.

Your Secretary attended, as the representative of the Society, the meetings of the corresponding Societies at the British Association. He presented the fourth report of the Committee for "ascertaining and recording the localities of the British Islands in which evidences of the existence of Pre-Historic Inhabitants of the country are found." The Committee consists of Sir J. Lubbock, Profs. Boyd Dawkins and Meldola, Drs. Evans, Munro, and Muirhead, Messrs. Pengelly and Hicks, with Mr. James W. Davis as Recorder and Secretary.

The Committee of the association for the Collection, Preservation and Systematic Registration of Photographs of Geological interest, was attended by three members of the Society, namely, Messrs. J. E. Bedford, R. H. Tiddeman and James W. Davis, who are members of the Committee.

A Committee was appointed for "the Investigation of the Cave at Elbolton, near Skipton, in order to ascertain whether the remains of Palæolithic man occur in the Lower Cave Earth." The Committee consists of 7 members of whom 4, viz :—James W. Davis (Chairman), Rev. E. Jones (Secretary), R. H. Tiddeman and J. J. Wilkinson are members of this Society. A grant of £25 was made to enable the Committee to carry on the work.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society,

1889-90.

Receipts.

	£	s.	d.
To Balance in hands of Treasurer, Oct. 31st, 1889	51	9	1
,, Subscriptions...	71	16	5
,, Interest on Halifax Corporation Bonds	11	1	8
,, Sundries	0	17	6
	£135	4	8

Expenditure.

	£	s.	d.
By Whitley and Booth—Printing ...	110	0	0
,, Expenses at Meetings, Postage, &c....	9	7	2
,, Subscription to the Geological Congress	1	1	0
,, Official Report of Scientific Societies	0	6	4
,, Cheque Book	0	2	6
,, Balance in hands of Treasurer ...	14	7	8
	£135	4	8

CAPITAL ACCOUNT.

	£	s.	d.
To Halifax Corporation Bond	350	0	0
,, Cash in hands of Treasurer	25	13	6
	£375	13	6

WM. CASH, Treasurer,
5th November, 1890.

Audited and found correct, 5th November, 1890.
GEORGE PATCHETT.

LIST OF MEMBERS.

Life members who have compounded for their annual subscriptions are indicated by an asterisk (*).

HONORARY MEMBERS.

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Williamson, Prof. W. C., F.R.S., Owen's College, Manchester.
Woodward, Henry, Esq., L.L.D., F.R.S., British Museum, (Natural History), London, S.W.

---

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Gregson, W., Baldersby, Thirsk.

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Lund, Percy, Ilkley.

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Mason, C. L., Leeds.
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Mitchell, Josh., F.G.S., Worsbro' Dale, Barnsley.
Mitchell, T. Carter, Topcliff, Thirsk.
Mitchell, T. W. H., Barnsley.
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Ormerod, Thomas, Fulham, London.

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*Ryder, Charles, Westfield, Chapeltown, Leeds.

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Scarborough Philosophical Society, J H. Phillips, (Scarborough).
Scratcherd, T. H. C., Halifax.
Seal, Henry, Vale Head, Knottingley.
Seal, Stephen, F.G.S., Darfield Quarries, Barnsley.
Shaw, John, Darrington Hall, Pontefract.

Shaw, Thomas, M.P., D.L., J.P., Allangate, Halifax.
Sladen, W. P., F.G.S., F.L.S., Linnean Society, Burlington House, London, S.W.
Slater, E., Ashville, Stanningley, Leeds.
Slater, M. B., Malton.
Slingsby, W. C., Carleton, near Skipton.
Smith, F., Huddersfield Road, Halifax.
Sorby, H. C., D.C.L., F.R.S., F.G.S., Broomfield, Sheffield.
Stanhope, W. T. W. S., J.P., Cannon Hall, Barnsley.
Stansfeld, A. W., Westgrove, near Leeds.
Stather, J. W., 226, Spring Bank, Hull.
Steel, R. Elliott, M.A., Hawthorn House, Baildon, Bradford.
Stephenson, M., Queen's Road, Harrogate.
*Stockdale, T., Spring Lea, Leeds.
Stocks, Michael, junior, Shibden Head, Halifax.
Stott, W., Greetland, near Halifax.
Strangways, C. Fox, F.G.S., of H.M. Geological Survey, 5, Belgrave Crescent, Scarborough.
*Strickland, Sir Charles W., Bart., Hildenley, Malton.
Sugden, Richard, ye Farre Close, Brighouse.
Swallow, D., Gas Works, Bradford.
Sykes, Peace, 33, Estate Buildings, Huddersfield.
Sykes, Sir Tatton, Bart., Sledmere House, near York.

Tate, Thomas, F.G.S., 5, Eldon Mount, Leeds.
Taylor, John Henry, Borough Surveyor, Barnsley.
Taylor, J. D., Halifax.
Tennant, J. R., 62, Brunswick Place, Brighton.
Tetley, Mrs., Foxhills, Weetwood, Leeds.
Tetley, C. F., M.A., Spring Road, Headingley, Leeds.
*Tew Thomas W., J.P., Carleton Villa, near Pontefract.
Travis, Rev. W. Travis, Ripley.
Thompson, J. C., Selby.
Thompson, R., Dringcote, The Mount, York.
*Tiddeman, R. H., M.A., F.G.S., of H.M. Geological Survey 28, Jermyn Street, London.
Townend, Walter, Bradford.
Turner, R. Bickerton, J.P., Oak Leigh, Buxton.

Tute, Rev. J. Stanley, B.A., Markington, Ripley.

Utley Samuel, Halifax.
Utley William, Halifax.

Veitch, W. Y., M.D., 37, Grange Road, Middlesborough.
Vine, George R., 112, Hill Top, Attercliffe, Sheffield.

*Walmisley, A. T., C.E., F.S.I., F.K.C., 5, Westminster Chambers, Victoria Street, London.
*Ward J. Whiteley, J.P., F.R.M.S., South Royd, Halifax.
Wharncliffe, Earl of, Wortley Hall, Sheffield.
Wheatley, Charles, Sands House, Mirfield.
White, J. Fletcher, 24, St. John's, Wakefield.
*Whiteley, Fredk., Clare Road, Halifax.
Wilkinson, J. J., Skipton.
Wilson, Edmund, Red Hall, Leeds.
Wilson, E. J., M.A., 6, Whitefriars' Gate, Hull.
Woodall, J. W., J.P., F.G.S.. Old Bank, Scarborough.
Woodhead, Joseph, M.P., J.P., Longdenholme, Huddersfield.

⁂ It is requested that Members changing their residence will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1890.

SHEET 1.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, M. Inst. C.E. retired, F.R.A.S., F.R.Met Soc., F.G.S., and Alfred Eley Preston, M. Inst. C.E., F.R.Met.Soc., F.G.S.
Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

MONTHS.	PRESSURE OF ATMOSPHERE IN MONTH.										
	Highest Reading of Barometer.	Date.	Highest during 22 Years.	Mean of Highest of 22 Years.	Lowest Reading of Barometer.	Date.	Lowest during 22 Years.	Mean of Lowest of 22 Years.	Range.	Corrected for Capillarity and Temperature. Mean	Corrected for Capillarity and Temperature. Mean of 22 Years.
	Ins.	On	Ins.	Ins	Ins	On	Ins.	Ins	Ins	Ins	Ins
January	30 038	29th	30 544	30 175	28 316	23rd	28 070	28·678	1 722	29 417	29 519
February	30 376	23rd	30·412	30 092	29 272	16th	28 462	28 801	1 101	29 864	29 518
March	30 203	3rd	30 476	30 140	28 843	25th	28·175	28 775	1 360	29·389	29 494
April	29 021	1st	30 500	30 065	29 008	7th	28 332	28 837	1 013	29 436	29 470
May	30·103	22nd	30 382	30 054	29 100	11th	28 661	29 034	0 903	29 468	29 545
June	30 200	15th	30 300	30 023	28 848	30th	28 840	29 163	1 352	29 533	29 500
July	29·916	20th	30 305	29 971	29 023	1st	28 690	29 144	0 893	29 474	29 510
August	29·947	7th	30 232	29 980	28 990	26th	28 673	29 060	0 957	29 435	29 605
September	30 157	7th	30·232	30 088	29 236	20th	23 452	29·011	0 921	29 700	29 522
October	30·346	22nd	30 358	30 120	29 230	26th	28 250	28·742	1 116	29 635	29 460
November	30 080	20th	30 355	30 043	28 612	7th	28·154	28 679	1 468	29 433	29 445
December	30 096	30th	30·358	30 113	28 988	19th	27·652	28 681	1·108	29 648	29 478
Means, or totals	30 099		30 371	30 072	28 939		28 362	28 884	1 160	29 535	29 502

MONTHS.	TEMPERATURE OF AIR IN SHADE DURING MONTH. In Each Month									Daily Mean. In Each Month				Daily Mean. Range.	
	Highest	Date.	Highest during 22 Years.	Mean of Highest of 22 Years.	Lowest.	Date.	Lowest during 22 Years.	Mean of Lowest of 22 Years.	Range.	Of all Highest	Mean of 22 Years	Of all Lowest	Mean of 22 Years	Mean	Mean of 22 Years
	Deg.	On	Deg	Deg	Deg	On	Deg.	Deg	Deg.	Deg	Deg	Deg	Deg	Deg	Deg
January	54·8	7th	57·2	53 0	20 4	3rd	6 7	23 7	34 4	47 0	43 1	37 4	34 5	9·6	8 6
February	50 8	1st	59 8	53 4	29 4	28th	19·2	26 4	21 4	42 2	44 1	35 1	35 3	7 1	8 8
March	58 2	29th	66 0	56 9	26 0	31st	17 4	25 7	32 2	48·1	46 4	38 6	35 4	9 8	11 1
April	58 0	6th	74 0	63 8	32 2	1st	27·4	31 4	25 8	49 4	52 5	38 0	39 1	11 4	13 0
May	70 8	25th	83 9	70 3	37 6	31st	30 3	35 2	33 8	69 7	58 5	46 4	43 9	14 4	14 5
June	69 4	11th	87 8	77 0	41 5	8th	38 0	41 9	27 9	62 6	65 1	50 9	51 1	11 7	14 9
July	70 3	22nd	89 6	79 5	46 6	20th	40·0	46 4	23 7	63 4	68 1	52 7	[illegible]	10 7	14 3
August	75 0	6th	85 2	78 3	42 0	31st	38 6	45 2	33 0	63 8	67 0	52·0	53 6	11 8	14 0
September	76 4	14th	83 3	70 7	41 0	1st	33 5	39 8	35 4	65 4	62 6	52	49 6	12 6	12 3
October	65 3	13th	69 9	63 2	28 6	28th	26 7	32 4	36 7	55 1	53 8	45 8	43 3	9 3	10 5
November	56 6	20th	66 5	56 4	27 0	27th	23 0	26 6	29 6	48 7	47 4	38 0	38 4	10 7	9 0
December	52 8	2nd	57 8	53 0	18 4	22nd	13 9	23 3	34 4	38 9	42 6	29 6	34 2	9 3	8 5
Means, or totals	63 2		72 8	64 6	32 5		26 3	33 3	30 7	53 8	54 2	43 1	42 6	10 7	11 6

MONTHS.	Adopted Mean Temperature. Of Dry Bulb		Of Air		Of Evaporation		Dew Point		Elastic Force	
	Mean	Mean of 22 Years	Mean.	Mean of 22 Years	Mean	Mean of 22 Years	Mean	Mean of 22 Years	Mean	Mean of 22 Years
	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Ins	Ins
January	42 0	39 3	42 0	38 9	40 1	37 2	37 7	34 9	227	215
February	36 0	36 6	38 1	39 5	36 3	37 7	33 9	35 4	195	208
March	43 9	40 6	43 2	40 1	40 5	37 8	37 3	34 8	223	203
April	43 5	44 7	42 9	44 1	39 5	41 3	36 4	37 4	217	226
May	52 6	49 7	52 2	49 6	47 4	45 1	42 5	41 1	273	259
June	55 8	55 8	55 4	55 7	51 6	51 [illegible]	48 0	46 8	[illegible]	321
July	58 1	60 [illegible]	57 2	59 8	51 8	54 2	46 9	50 0	321	361
August	56 6	58 8	56 5	58 [illegible]	52 [illegible]	53 [illegible]	48 4	50 1	341	363
September	58 5	54 6	58 2	54 7	54 5	51 4	51 2	48 0	377	337
October	49 9	48 2	49 7	47 9	46 6	45 5	43 [illegible]	42 7	282	276
November	42 3	42 8	42 6	42 5	40 8	40 3	36 7	37 5	215	225
December	33 5	38 9	33 9	38 6	32 5	36 7	30 [illegible]	34 2	167	199
Means, or totals	47 9	47 8	47 7	47 5	44 5	44 4	41 1	41 1	265	265

MONTHS.	VAPOUR. In a Cubic Foot of Air						Degree of Humidity (Complete Saturation = 100)									
	Mean	Mean of 22 Years	Short of Saturation	Mean of 22 Years	Mean Weight of a Cubic Foot of Air	Mean of 22 Years	Highest	Date	Highest during 22 Years	Mean of Highest of 22 Years	Lowest	Date	Lowest during 22 Years	Mean of Lowest of 22 Years	Mean	Mean of 22 Years
	Grs	Grs	Grs	Grs	Grs	Grs	0–100	On	0–100	0–100	0–100	On	0–100	0–100	0–100	0–100
January	2 6	2 4	0 6	0 4	543	540	97	28th	100	97	57	3rd	[illegible]	66	86	86
February	2 3	2 4	0 5	0 4	556	548	97	24th	100	97	54	6th	42	66	85	86
March	2 6	2 4	0 6	0 5	542	547	94	2nd	99	96	53	[illegible]	33	67	80	83
April	2 1	2 6	0 8	0 8	543	541	[illegible]	[illegible]	100	95	[illegible]	[illegible]	[illegible]	52	75	77
May	3 1	3 0	1 3	1 1	533	537	90	[illegible]	[illegible]	[illegible]	[illegible]	29th	[illegible]	41	70	73
June	3 8	3 6	1 2	1 4	530	531	91	9th	100	93	[illegible]	1st	[illegible]	48	77	72
July	3 6	4 0	[illegible]	1 7	528	526	91	[illegible]	99	91	47	15th	45	48	[illegible]	[illegible]
August	3 8	4 1	1 3	1 5	528	527	92	11th	99	[illegible]	[illegible]	6th	41	51	[illegible]	74
September	4 1	3 9	1 2	1 0	530	531	91	[illegible]	[illegible]	96	[illegible]	8th	[illegible]	[illegible]	[illegible]	78
October	3 2	3 2	0 5	0 7	[illegible]	538	96	22nd	99	97	[illegible]	7th	[illegible]	[illegible]	[illegible]	83
November	2 7	2 6	0 5	0 5	543	[illegible]	97	14th	100	[illegible]	[illegible]	9th	[illegible]	63	86	83
December	1 9	2 3	0 4	0 5	557	548	96	24th	[illegible]	97	46	20th	41	64	85	84
Means, or totals	3 0	3 0	0 9	0 9	539	539	96		100	95	48		[illegible]	66	79	79

MONTHS.	BRIGHT SUNSHINE.				TEMP. OF AIR IN SUN'S RAYS.			WIND. Direction: Relative Proportion of at 9 a.m.							
	Greatest Daily Duration.	Date.	Total of Month.	Per cent. of Possible Duration.	Highest.	Date.	Mean.	N	NE	E.	SE.	S	SW.	W.	NW.
	hr min	On	hr min		Deg	On	Deg	No	No	No	No	No	No	No	No
January	5 10	28th	25 25	10	75 0	28th	61 6	6	0	0	1	2	13	5	0
February	6 0	3rd	19 35	7	80·0	3rd	69 8	11	8	2	2	0	2	1	2
March	8 20	31st	65 45	18	99 5	31st	76 1	5	1	0	2	6	7	9	1
April	7 45	23rd	73 35	18	103 0	28th	82·2	15	3	2	1	3	5	1	0
May	14 25	26th	132 20	27	110·2	26th	95 8	8	5	5	2	2	3	4	2
June	11 10	1st	75 [illegible]	15	111 0	16th	98·5	2	1	2	0	2	6	15	2
July	10 30	25th	108 15	21	107 0	31st	95·8	5	3	0	0	0	8	13	2
August	10 20	17th	111 30	24	107 6	17th	97 8	2	3	0	4	1	7	7	7
September	7 30	14th	116 45	29	107 8	8th	97 7	0	0	1	9	1	9	6	4
October	7 30	4th	73 40	23	102 0	13th	82 9	1	3	0	0	1	9	8	9
November	4 45	2nd	28 15	11	89 0	2nd	65·7	0	4	0	3	0	11	1	11
December	0 0	...	0 0	0	53 0	8th	45·7	2	15	0	10	0	2	1	1
Means, or totals	7 47		824 5	18½	95 4		80 2	60	46	12	34	18	82	71	46

MONTHS.	WIND. Velocity. At 9 a.m.			During 24 hours.				Pressure.						Mean Amount of Cloud.	RAIN.							Greater fall on surface at Town Hall & Mid Stn than at 65½ft. above surface at Exch	
	Mean.	Highest.	Date	Mean.	Highest.	Date	Total Registered in Month.	Mean of all Daily Highest.	Mean of all Daily Highest of 7 Years.	Highest.	Direction.	Date	Mean of Highest of Month of 7 Years.		Number of Days it fell.	Greatest Daily Fall.	Date.	Amount Collected	Mean of 21 Years	Mean of Seven Years ending with 1882, 65½ft. above surface of ground.	Mean of 7 Yrs ending with 1882 at Tn Hall and Mid Ry Station on surface of ground.	Depth in Inches.	Percentage of fall at Exch'ge
	Miles p'r hr	Miles p'r hr	On	Miles per d	Miles per d	On	Miles.	lb. per sq ft	lb. per sq ft	lb. per sq ft		On	lb. per sq ft	0–10	No	Ins	On	Ins	Ins	Ins	Ins	Ins	Per cent
January	8 3	28 0	26th	217	413	6th	6724	2 67	3 04	14 00	S W	19th	12 75	7 6	24	1 48	22nd	4 39	2 67	2 209	2 474	0 265	11 2
February	5 9	10 3	26th	136	227	27th	3812	0 98	2 71	3 50	N E	27th	9 46	8 3	11	0 41	16th	0 72	1 83	2 609	2 972	0 363	11 4
March	7 2	15 4	15th	187	325	11th	5803	2 62	2 25	7 00	W	8th	9 71	6 7	20	0 46	24th	1 83	2 20	2 776	3 260	0 484	11 7
April	7·0	18·8	22nd	136	359	23rd	4074	1·59	2·31	7·50	S W	23rd	8·11	6·7	14	0·34	7th	0·87	2·08	2 516	2·835	0·319	11 2
May	6 4	13 3	25th	137	246	21st	4242	1 23	2 18	4 00	S E	21st	7 89	5·4	12	0 72	12th	2·57	1·83	2·103	2 277	0 174	10 8
June	5 4	11 0	1st	115	230	4th	3440	1 53	1 56	4 50	W	18th	6 68	8 0	13	1 02	11th	1 98	2 26	2 837	3 011	0 174	10 6
July	6 1	18 0	14th	132	271	14th	4677	2 16	1 68	7 00	W	23rd	5 86	6 5	19	0 88	1st	2 45	2 94	3 401	3 641	0 240	10 7
August	4 8	12 2	15th	106	230	16th	3261	1 53	1 57	9 00	S W	16th	6 75	6 3	20	0 84	11th	4 35	2 62	3 654	3 892	0 238	10 7
September	5 2	14 4	21st	109	233	30th	3263	1 72	1 89	6 00	W	30th	6 32	6 4	10	0 42	4th	1 40	2 64	2 804	3 229	0 315	11 2
October	7 3	16 6	5th	155	311	1st	4805	2 07	2 29	7 50	S W	30th	8 68	7 0	15	0 24	26th	1 20	3 42	3 640	4 012	0 372	11 0
November	6 6	14 0	30th	149	313	23rd	4477	2 05	2 38	7 25	S W	23rd	9·46	7 1	21	0 62	7th	3 17	2 91	3 421	3 828	0 427	11 2
December	4·8	11·8	30th	118	307	5th	3658	0 82	2·49	3 00	N E	4th	9 88	9 8	15	0·14	24th	0 64	2 66	3·681	4 170	0 489	11·3
Means, or totals	6 3	15 3		141	289		51636	1 76	2 20	6 00			8 46	7 1	191	0 63		25 57	29 06	35 741	39 601	3 860	11 08

METEOROLOGY OF BRADFORD FOR 1890.

SHEET 2.

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, BRIGHT SUNSHINE, WIND PRESSURE, AND RAINFALL.

Year.	Pressure. Highest. Reading of Barom during Year.	Pressure. Highest. Date.	Pressure. Lowest. Reading of Barom during Year.	Pressure. Lowest. Date.	Temperature. In Shade. Highest. R'ding of Maximum Thermom during Yr.	Temperature. In Shade. Highest. Date.	Temperature. In Shade. Lowest. R'ding of Minimum Thermom during Yr.	Temperature. In Shade. Lowest. Date	Temperature. Last and First Frost of Seasons. Date of Last Frost.	Temperature. Last and First Frost of Seasons. Date of First Frost.	Temperature. In Sun's Rays. Highest. Reading of Solar Thermom during Yr.	Temperature. In Sun's Rays. Highest. Date	Humidity. (Complete Saturation = 100.) Highest. Degree of Humidity during Yr.	Humidity. Highest. Date	Humidity. Lowest. Degree of Humidity during Yr.	Humidity. Lowest. Date	Bright Sunshine. Greatest Daily Duration	Bright Sunshine. Date	Bright Sunshine. Total of Year	Bright Sunshine. Per cent of Possible Duration	Wind Pressure. Highest	Wind Pressure. Date	Rain. Total for Year	Rain. Mean Y'rly Rainfall at Town Hall and Mid Rly Stn on surface of g'nd	Rain. Gr'tr fall on srfce. at Tn H'll & Mid Stn than at 65½ ft above surf at Exe. Depth in Inches	Rain. Gr'tr fall on srfce. Percentage of fall at Exch'ge	Rain. Greatest Daily Fall during Yr.	Rain. Date	Snow. Last and First Snow of Seasons. Date of Last Snow	Snow. Date of First Snow
	Ins		Ins		Deg.		Deg.				Deg		0 100		0 100		hr min.		hr min		lb per sq ft		Ins	Ins	Ins	Per cent	Ins			
1869	30 290	Dec. 6	28 500	Feb. 1	85 2	Aug 30	19 8	Dec 28	Mar. 27	Oct 20	127 7	Aug 30	99	Feb 8	42	Sep 24													April 3	Oct 19
1870	30 284	Jan. 19	28 308	Jan. 8	85 0	July 25	16 6	Dec 23	Mar 30	Nov 9	127 5	July 25	98	Jan. 29	28	Mar 6							24 125				0 820	June 18	Mar 24	Nov 15
1871	30 152	Mar 28	28 308	Jan 16	84 0	Aug 12	6 7	Jan 1	April 11	Nov 13	128 7	July 17	98	July 7	43	Nov 2							21 640				0 915	June 16	Mar 15	Nov 16
1872	30 156	April 6	28 070	Jan 24	86 4	July 23	24 8	Mar 27	Mar 27	Nov. 19	124 8	Aug 19	100	Mar 22	45	Sep 23							42 060				2 440	June 19	May 11	Nov 13
1873	30 338	Feb 18	28 022	Jan 20	88 8	July 23	19 2	Feb 24	Mar 14	Nov 5	124 5	July 23	100	Dec 11	41	Mar 26							21 440				1 200	Aug 4	April 25	Jan 3, '74
1874	30 476	Mar. 6	28 276	Dec 11	80 9	July 20	15 0	Dec 31	Mar 12	Nov 11	125 8	July 20	100	Feb 6	42	May 18							23 560				0 740	Dec 7	May 9	Nov 26
1875	30 305	July 7	28 484	Nov 10	80 0	Aug. 17	13 0	Jan 1	Mar 22	Nov 26	122 0	July 5	100	Jan 23	43	July 6							30 280				1 700	Nov 15	Mar 12	Nov 9
1876	30 300	Jan. 15	28 070	Dec 4	87 6	July 17	23 0	Jan. 9	April 15	Nov 9	125 6	July 16	99	Oct 4	46	May 5							35 270	39 788	4 518	11 28	1 813	Oct 9	April 12	Nov 8
1877	30 358	Oct 6	28 300	Nov 29	80 0	June 19	20 0	Mar 1	May 4	Oct 18	116 4	June 19	100	Oct 29	36	May 23							40 650	45 499	4 849	11 19	1 426	July 16	May 19	Oct 16
1878	30 320	Mar. 16	28 630	April 1	89 6	July 19	13 9	Dec 26	April 6	Nov 9	118 2	July 22	99	Jan 13	53	Aug 9							35 434	39 010	3 576	11 01	1 220	Aug 14	April 1	Nov 8
1879	30 352	Dec 13	28 500	Feb 10	74 4	July 30	13 2	Dec 7	May 10	Nov 14	101 2	Aug 13	100	Oct 7	51	Dec 12							28 017	30 298	2 281	10 82	1 020	June 8	May 7	Nov 20
1880	30 332	Jan 7	28 164	Nov 16	81 3	Sep 5	20 8	Jan 20	Feb 23	Oct 20	112 0	Aug 13	99	Dec 15	50	May 30							35 690	39 616	3 926	11 10	1 710	Oct 27	Mar 2	Oct 27
1881	30 382	May 10	28 250	Oct 14	83 3	July 6	12·0	Jan 26	April 21	Oct 17	116 5	June 1	98	Oct 14	38	May 31							36 434	39 892	4 468	11 26	1 435	Oct 13	April 20	Oct 29
1882	30 544	Jan 18	28 452	Mar. 1	77 4	Aug 12	18 6	Dec 11	April 16	Nov 12	108 0	Aug 9	99	Nov 6	36	May 18							33 683	43 103	3 420	10 86	1 608	Dec 6	Mar 21	Nov 19
1883	30·500	April 8	28 452	Sep. 2	76·2	July 3	19·8	Mar. 10	Mar. 29	Nov. 12	107·6	May 17	99	Dec. 26	30	April 9	......	......	......	......	......	......	34 396	......	......	......	1 338	Sep 26	Mar 24	Nov 10
1884	30 354	Oct 8	28 376	Jan. 27	84 4	Aug 12	26 5	Nov 30	April 24	Nov 24	107 8	Aug 9	98	Jan. 25	30	May 22	......	...	.		24 00	Jan 24	27 657				1 170	Jan 23	Feb 28	Nov 23
1885	30 273	Mar. 14	28 400	Jan. 11	82·2	July 27	22·1	Dec. 11	April 5	Nov. 16	113·6	July 27	100	Jan. 23	32	June 4	......	......	.....		15 25	Dec 4	25 699				1 208	Sep 3	May 7	Dec 9
1886	30·355	Nov. 24	27·652	Dec. 8	79·5	July 3	17·4	Mar. 7	April 30	Dec. 2	108 8	July 5	99	Jan 12	32	May 4	11 45	July 6	851 48	19	18 00	Dec 9	35 993				2 140	July 26	May 12	Nov 6
1887	30 412	Feb. 8	28 328	Nov. 3	82·8	July 9	21 1	Jan 17	April 17	Oct 12	107 6	July 9	100	April 21	35	July 9	12 40	July 3	1120 58	25	15 00	Feb 4	18 665				0 810	Oct 9	May 21	Oct 14
1888	30 333	Jan. 10	28 410	Mar. 28	80 4	June 27	19 2	Feb 14	April 8	Oct. 2	110 0	Sep 15	99	Mar 15	39	June 11	13 40	May 24	984 20	20	13 00	May 4	25 646				1 050	Nov 5	April 8	Oct 1
1889	30 358	Dec. 5	28 460	Mar. 20	77 5	Aug 1	27·3	Mar 4	Mar 22	Nov 27	115 2	June 23	99	April 22	39	June 26	12 15	July 8	827 45	18	12·00	Feb 9	22 110				1 540	Mar 9	Mar 21	Nov 25
1890	30 376	Feb. 23	28 315	Jan. 23	76 4	Sept. 10	18 4	Dec. 22	Mar 10	Oct 28	111·0	June 16	99	May 11	31	May 29	14 25	May 25	824 5	19	14 00	Jan 19	25 730				1 485	Jan 22	April 15	Oct 21
Means	30 345		28 305		82 0		18 3				116 4		99		33		12 57		901 47	20	15 89		29 962	39 601	3 860	11·08	1 330			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8.40 p.m. the mercury of the Exchange barometer had fallen to 27·466 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

Bright sunshine is recorded in hours and minutes by glass sphere on cards, known as Campbell's recorder, fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a.m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·86 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the twenty-one years ending with 1890 is 29·962 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 33·282 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

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